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WADC TECHNICAL REPORT 55-83

THE DEVELOPMENT OF WOOL-SYNTHETIC BLENDED FABRICS FOR SUMMER FLIGHT GARMENTS

GEORGE O. LANGLAIS
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LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION

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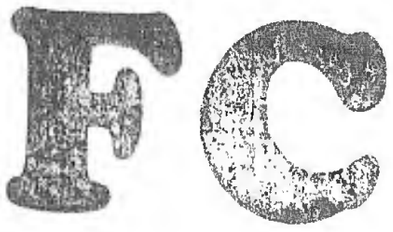

WRIGHT AIR DEVELOPMENT CENTER

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MATERIALS LABORATORY
CONTRACT No. AF 33(600)-25892
PROJECT No. 7320
TASK No. 73202

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.
400 - April 1956

FOREWORD

This report was prepared by the Lowell Technological Institute Research Foundation under United States Air Force Contract No. AF 33(600)-25892. The contract was initiated under Project No. 6314, "United States Air Force Uniform Clothing Assemblies," Task No. 64499, "Summer Flight Garment Fabrics," and was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. C. W. Long acting as project engineer.

The yarn processing involved in this study was performed by the Ames Textile Corporation. The finishing of the wool-synthetic test blends was accomplished under the supervision of Prof. J. J. MacDonald at the Lowell Technological Institute Research Foundation in accordance with the recommendations of Mr. P. DeMallie and Mr. A. Weldon of E. I. du Pont de Nemours & Company, Inc., and Mr. H. Pero of Carbide and Carbon Chemicals Company who were present during the operations. All the weaving and the finishing other than that already mentioned were accomplished by Methuen International Mills. The Dynel used in the manufacture of the final fabric was dyed by the Robinson Top Dye Company under the direction of Carbide and Carbon Chemicals Company; the wool for this fabric was dyed by the Ames Textile Corporation using a formula developed by them.

The cooperation and interest in this program shown by the following individuals and their organizations are gratefully acknowledged: Mr. P. DeMallie and Mr. A. Weldon; Mr. H. Pero; Mr. A. Coffin and Mr. G. Archer of Ames Textile Corporation; and Mr. J. K. Selden and Mr. G. E. Coates of Methuen International Mills.

This report covers work conducted from September 1954 to March 1955.

ABSTRACT

A study of wool-synthetic blend fabrics was made to develop one suitable for summer flight clothing.

A survey of worsted manufacturers was conducted to obtain commercially available blend fabrics that approximated the basic requirements. The results of tests performed on the fabrics obtained were considered in subsequent design and manufacture.

Identically constructed fabrics composed of blends of nylon, Dacron, Orlon, and Dynel (each blended at 15%, 30%, and 60%) with wool and an all-wool control were produced; these were tested and compared with respect to fabric properties.

Particular emphasis on the flame-resistance characteristics, specifically centered on the degree of melting and "dripping" after ignition - indicated of major consequence in the establishment of this program - led to the selection of the final fabric, a 70% wool-30% Dynel fabric.

The unfavorable results obtained in this program on any of the synthetic fiber-wool blends and constructions, is not to be construed as an indication of the performance of other blends or constructions or where other parameters of tests and performance are stipulated.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE [illegible]MMANDER:

M. R. WHITMORE
Technical Director
Materials Laboratory
Directorate of Research

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I INTRODUCTION

The development and test of a wool-synthetic blend fabric suitable for fabrication of summer flight clothing was the objective of this study.

The target properties of the fabric desired are presented in Table 1.

The synthetic fibers included in this study were nylon, Dynel, Dacron, and Orlon (Type 42). The possibility of blends of these satisfying the fabric properties desired was considered in this selection. Also considered were the stabilized status of their structures (i.e., they were not experimental fibers or considered subject to substantial changes) and that these fibers were readily available.

The project procedure was initially established and subsequently adhered to as follows:

1. To survey domestic worsted manufacturers and thereby obtain samples of all commercial fabrics which approximate the basic requirements other than color.

2. To test and evaluate all suitable commercial fabrics thereby obtained, with special emphasis on flame resistant properties.

3. To design a series of fabrics, based on the results of these tests, of such composition and structure that the target properties (other than color) would be realized.

4. To test and evaluate the fabrics and to establish the fabric composition and structure most suitable in light of the target properties.

5. To develop a dye formulation for Sage Green 527 to fulfill the color requirement.

6. To manufacture the required yardage of the fabric developed for submission in fulfillment of the contractual commitment.

It was hoped that the commercial samples obtained in the survey would provide sufficient diversification of composition and construction to permit the establishment of fundamental requirements for the end-properties sought.

The characteristic of the fabric desired emphasized as of the greatest consequence was that of flame-resistance, particularly in terms of the melting and "dripping" of a material upon ignition by a flame.

The tests performed on the various fabrics procured and produced were conducted in accordance with the methods listed in Table 1 whenever feasible.

II SURVEY OF INDUSTRY

In order to obtain as many commercial worsted wool-synthetic blend samples as possible, 224 textile manufacturers were contacted. The samples received from them are summarized in Table 2.

It is unfortunate that only eighteen samples were received and that fourteen of these eighteen were wool-Dacron blends, thus limiting the scope of this phase.

The samples were analyzed and tested. Detailed descriptions of the methods followed and the results obtained are given in Table 3. Graphical presentations of the results appear in Figures 7 - 16.

Consideration of Samples Nos. 3, 12, 14, and 17 was discontinued following the tests reported in Table 3, for these fabrics exceeded the maximum weight specification. Consequently, none of these appear in Figures 7 - 16, and no further references are made to them herein.

Additional analytical data were obtained on fabrics of the proper weight and air permeability characteristics to meet the requirements of the contract. These are presented at the end of Table 3.

Only physical tests were applied in the analyses of the samples. The evaluation was conducted on the assumption that all the samples contained a pure finish, i.e., that no finishing agent that would affect the parameters measured significantly had been applied on the fabrics.

Discussion

General indications only could be observed in this study due to the many variables present.

Pilling resistance was not measured directly. Observations on pilling were made during the abrasion tests. None of the samples showed any evidence of pilling.

In the flame-resistance tests, three fabrics, Samples Nos. 2, 6, and 19 - the latter two were the only Dynel blends involved in the study - did not ignite when subjected to the 45^0 angle test (Figure 15). Sample No. 2, 60-40 wool-Dacron, did not ignite while Sample No. 1, also composed of 60 - 40 wool-Dacron, did ignite and burn (Figures 15 and 16). The two fabrics were different in construction and weave formation - and, conceivably, possibly in finishing treatment; the many variables existent precluded assigning the reason for dissimilarity in flame-resistance to specific factors. It is to be noted, however, that all the fabrics that did not ignite or that displayed a burning time (seconds to burn 5 inches of fabric) in excess of 26 seconds were plain weaves; the other

fabrics made with a plain or a twill weave had burning times of shorter duration (26 to 13.5 seconds).

An important factor in flammability is whether the fabric is "tight" or "loose." A "tight" structure allows less air to surround the fibers and thus support combustion. A plain weave provides a relatively "tight" structure compared to that of a twill weave.

This factor also affects air permeability. Theoretically, a plain weave should resist air flow to a greater degree than a twill weave (1) by virtue of the reduced pore areas present, due to the greater number of interlacings of warp and filling yarns. Figures 1 - 4 were prepared to illustrate this point.

No correlation between weave formation and air permeability measurements could be drawn in this study (Figure 7).

The air permeability values of the two wool-Dynel blends were low. A contributory factor may be that the Dynel fiber is flat in cross section (2), and, when spun into a yarn with wool, it would tend to produce a flat-type yarn. This has been visually observed in cases of wool-Dynel yarns. Flat yarns tend to reduce pore areas resulting in low air permeability.

The greatest air flow was through Sample No. 4 (100% Dacron).

Sample No. 10 displayed the highest resistance to flex abrasion (Figure 12). This fabric, composed of 50 - 50 wool-Dacron, differed from the other blends in that it was yarn-blended rather than fiber-blended. Separate singles yarns of each fiber (wool and Dacron) were twisted together to make the plied yarns used to produce the fabric (Figures 5 and 6). In the flex abrasion test of this fabric although the wool yarn wore away easily, the Dacron yarn continued to resist abrasion. It is not considered prudent manufacturing technique to prepare fabrics in this manner unless designing for a specific end-use. It is a less costly method. Fabrics fashioned after this pattern are difficult to control in the finishing operations.

The overall results of the flex abrasion tests cannot be as sharply defined as those of the surface abrasion tests. Without exception the blend fabrics made with twill weaves performed better in surface abrasion than those made with a plain weave (Figure 13); generally speaking, the twills appeared to offer greater resistance to flex abrasion also (Figure 12). The superior behavior of twills in both properties may possibly be assigned to the greater flexibility of a twill, a consequence of the fewer interlacings present in its structure.

Although outshone by the Dacron blends, the Dynel blends compared well with them with respect to crease recovery (Figure 14).

General conclusions drawn in this evaluation, based on fabrics having approximately the same weight, are summarized as follows:

1. The type of weave appears to have a direct effect on surface abrasion and flex abrasion. Twill weaves appear to offer greater resistance than plain weaves in both cases.

2. Plain weaves apparently offer more resistance to flame than twill weaves.

3. Dynel seems to contribute to a worsted fabric in the parameters of flame-resistance and crease recovery.

III DEVELOPMENT OF WOOL–SYNTHETIC TEST BLENDS

A basic fabric design was established using the information obtained in the tests on the commercial fabrics and following recommendations supplied by industry.

Two of the eighteen commercial samples tested (Samples Nos. 10 and 11) were of the proper weight and (air) permeability to satisfy the requirements of this contract. The construction of Sample No. 10 (Table 3) was incorporated in the design of the basic fabric, the yarn count of this sample being considered more amenable to small lot production.

Thirteen fabric samples, including an all-wool control and three blends (at the levels of 15, 30, and 60%) of each of four synthetic fibers (nylon, Dacron, Orlon, and Dynel) with wool were produced as described in Table 4. Descriptions of the fibers used are also given in Table 4.

In this production all construction and processing variables (through weaving) were maintained as constant as possible. No variation was introduced to compensate for the different densities of the various fibers involved. Therefore the yarns produced although identical in weight differed slightly in diameter. This factor was considered, but it was not believed to be of sufficient consequence to demand the introduction of the many changes in settings that would have been required to adjust for it. The similarity of the fabrics produced to conventional commercial fabrics was sufficient to insure the value of the results of the tests performed on them. It was also considered that although all conditions were similar in preliminary processing, some allowance in finishing would be possible to obtain, if necessary, variations in the fabric count to adjust the weight and, possibly, the air permeability.

The thirteen lots were spun on the Bradford system into 2/45s (worsted) yarns with 19 T. P. I. of "Z" twist in the single and 19 T. P. I. of "S" twist in the ply.

Consideration was given to using a greater twist in the ply than in the singles in order to assure that the fabric would resist pilling to a satisfactory degree. However, worsted manufacturers in this country use a balanced twist to provide better all-around performance in apparel fabrics.

The fabrics were woven on Crompton & Knowles W-3 looms using a 2/1 right hand twill.

The finishing procedure to be followed with each fabric was established in conference with representatives of the synthetic fiber manufacturers concerned. Included in the decisions made at this conference was that of dyeing the stock used in producing the final fabric prior to fabric manufacture. This eliminated the need for simulated dyeings of the trial pieces to assure agreement between

the results of the immediate work being resolved and that of subsequent phases.

The finishing operations applied on the fabrics are described in Table 5.

Following final processing the fabrics were tested as described in Table 6. With the exception of those obtained in the pilling and sewability tests, the results are presented graphically in Figures 17 - 26.

Discussion

The air permeability ratings of all samples were low - not in the required range (Figure 17). Depressed ratings were obtained with increased contents of nylon, Dacron, or Dynel. Although an intermediate content (30%) of Orlon reduced permeability, a content of 60% appeared to increase it.

The presence of nylon or Dacron in any amount in the fabric improved the breaking strength, that of Dynel when it exceeded 15%, and that of Orlon apparently only when it exceeded 42% (Figure 18).

Dynel and Orlon did not affect tear strength to an extensive degree; a slight decrease was indicated by the blends of these fibers, those of Orlon showing the greater decrease. Tear strength improves substantially with increased contents of nylon or Dacron, the effect of the former being the greater (Figure 19).

Improved shrinkage to laundering is provided by increased contents of nylon or Dacron. The effect of Dacron is the greater (Figure 20).

All the blend fabrics displayed improved shrinkage in dry-cleaning. The one containing 60% Dacron displayed the least shrinkage (Figure 21).

In shrinkage to laundering, the blends containing 15% and 30% Dynel compared favorably with those of the other synthetic fibers at the same level of blending. In shrinkage to dry-cleaning, the 15% and 30% Dynel blends were outstanding in comparison with equivalent blends of other fibers.

Dynel and Orlon did not improve flex abrasion. Both nylon and Dacron effected a substantial improvement of this property (Figure 22).

The Dacron blends were outstanding with respect to resistance to surface abrasion. The improved effects in this property provided by contents of nylon were substantial, those of Orlon or Dynel were slight (Figure 23).

The blends containing 15% and 30% synthetic fiber were essentially equal to the all-wool control with respect to crease recovery. All those containing 60% synthetic fiber were approximately equal to or poorer than the control (Figure 24).

In the flame-resistance tests, all the fabrics ignited and burned. All the fabrics dripped profusely except the all-wool control and the three Dynel blends (Samples Nos. 1, 11, 12, and 13, respectively). The data obtained in these tests are illustrated in Figures 25 and 26.

In the pilling resistance tests no pills were produced on any of the fabrics. This is not considered as an indication that the thirteen fabrics would resist pilling (and do so equally well) in actual wear.

In general, a 15% content of synthetic fiber in a fabric appeared to improve seam efficiency; increased contents beyond that level tended to decrease seam efficiency. A series of blends that provide exceptions to these statements consists of those containing Dacron; these displayed poorer seam efficiency at the 15% and 60% content levels than the control and superior efficiency at the 30% content level. The Orlon blends exhibited the greatest efficiency - the fabrics containing 15% and 30% Orlon showing seam efficiency superior to that of all the other fabrics.

The all-wool control appeared best with respect to yarn severance in the sewability tests. Samples Nos. 2 and 12, containing 15% nylon and 30% Dynel, respectively, appeared poorest.

Conclusions

In consideration of the primary target properties established in this project, which were the flame-resistant characteristics, a blend containing Dynel appeared satisfactory. To fulfill the other (i.e., the secondary) properties, the blend selected was of the same composition as that of Sample No. 12, viz., 30% Dynel - 70% wool.

Particular emphasis was placed on the melting and dripping behavior of the material composition of fabrics when exposed to flame. The only blend fabrics that did not exhibit such phenomena were those containing Dynel.

In hopes of obtaining a fabric that would display increased resistance to flame, it was decided to change from the weave formation used in the production of the test fabrics, i.e., the 2/1 right hand twill, to a plain weave. The plain weave was indicated as possibly more flame-resistant in the tests performed on the commercial fabrics described previously.

The continuation of the project was consequently established as follows:

1. The design and production of a fabric sample composed of 70% wool - 30% Dynel, with a plain weave, and having the required weight and air permeability.

2. The production of the required yardage of such a fabric to fulfill the contractual obligations - this yardage to be dyed Sage Green 527.

IV DEVELOPMENT AND PRODUCTION OF WOOL-DYNEL FABRIC

A series of fabrics of the selected fiber blend, 70% wool - 30% Dynel, was produced to establish the relationship of fabric construction and air permeability. Variations in structure from that of Sample No. 12 that would permit the plain weave fabric under consideration to possess the proper weight and air permeability were fortunately derived in the first phase of this series.

The yarn was spun into a 2/30s worsted count with 15.5 T. P. I. of "Z" twist in the single and 15.5 T. P. I. of "S" twist in the ply.

A sufficient length of warp containing 46 ends/inch was dressed to permit weaving four five-yard sections of fabric, using a plain weave.

It was estimated that a final pick count in the range of 38 to 44 picks/inch in such a fabric would provide the air permeability and weight sought. To allow for fabric shrinkage from loom through finishing, the four sections of fabric were woven with pick counts ranging from 36 to 42 picks/inch, a change in pick count consisting of an increment of 2 picks/inch being introduced into successive sections (A, B, C, and D) processed.

The finishing of these fabrics is presented in Table 7.

The fabrics were tested for weight, fabric count, and air permeability (Table 8).

Two of the sections, A and B, met the requirements of weight and air permeability. Further tests then performed on Sections A and B are reported in Table 9.

Section A was approved by Wright Air Development Center as a standard for the manufacture of the final fabric.

The final fabric was produced using a procedure identical to that followed in manufacturing Section A described previously. The stock was dyed Sage Green 527 prior to fabric manufacture as follows:

The wool was stock-dyed with the formula presented in Table 10; the Dynel was top-dyed using the formula and procedure described in Table 11.

Colorfastness tests performed on a sample of the final fabric are presented in Table 12.

Discussion

A comparison of Section A, the fabric on which the final production was based, with Sample No. 12, the test blend of identical fiber composition that was

evaluated previously, can be made in a general manner; it cannot, however, be pursued with the goal of assigning a variation in properties to a specific change in structure due to the many factors that differ in the two, i.e., the weave, the yarn number and twist, and the fabric count.

Section A displayed greater flame-resistance than Sample No. 12; it sustained a shorter flame time and provided a shorter char length.

The air permeability of Section A was of the proper magnitude.

No sewability tests were performed on Section A.

The two fabrics, Sample No. 12 and Section A, were dissimilar in other properties; consideration of the warpwise and fillingwise properties of the two reflected the squarer construction of Section A.

TABLE 1

TARGET PROPERTIES

PHYSICAL PROPERTY	ESTIMATED VALUE	TEST METHOD, CCC-T-191b OR MODIFICATION THEREOF
1. Weight	6.5 to 7.5 ozs/yd^2	5041
2. Thread Count		5050
Warp and Filling		5100
3. Breaking Strength (Grab)		
Warp and Filling	50-120	5450
4. Air Permeability (cu ft/min/sq ft)		5134
5. Tear Strength		
Warp and Filling		5030
6. Thickness		5552 and 5550
7. Skrinkage in Laundering		5580
8. Shrinkage in Dry Cleaning		5110 and 5400
9. Fabric Sewability		
10. Colorfastness to:		5614
Laundering	Good	5660
Light	Good	5682
Perspiration	Good	5300 and 5302
11. Abrasion Resistance		5212
12. Crease Resistance		5902 and 5906
13. Flame Resistance		
14. Color	Sage Green 527	
15. Yarn Ply		
Warp and Filling	2	

***

The Fabric shall possess the following characteristics:

1. Fire resistant when exposed to flash fires.
   a. Slow rate of burning.
   b. Highest possible ignition temperature.
   c. Short existence of after glow.
2. Comfort - Shall be comfortable when worn in tropical or semi-tropical climates.
3. Appearance
   a. Shall be able to hold shape and not become baggy upon prolonged wear.
   b. Color retention.
4. Ability to wear well.
   a. Shall have good abrasion resistance.
   b. Shall have high tear resistance.
   c. Shall be resistant to pilling
   d. Seam durability.
5. Tailorability - Ability to withstand sewing on high speed machines without undue precautions which would delay fabrications.

TABLE 2

COMMERCIAL FABRICS RECEIVED AND TESTED

ASSIGNED SAMPLE NO.	FABRIC
1.	60% wool, 40% Dacron, 10.5 oz at 59 in.
2.	60% wool, 40% Dacron, 8.5 oz at 59 in.
3.	45% wool, 55% Dacron, 12 oz at 58 in.
4.	100% Dacron, 9.5 oz at 59.5 in.
5.	45% wool, 55% Dacron
6.	70% wool, 30% Dynel
7.	45% wool, 55% Dacron, 8.5-9 oz at 56 in.
8.	50% wool, 50% Dacron, 10.4 oz at 56 in.
9.	50% wool, 50% Dacron
10.	50% wool, 50% Dacron
11.	45% wool, 55% Dacron, 6-7 oz per sq yd.
12.	75% wool, 25% Dacron
13.	50% wool, 50% Dacron, 9-9.5 oz at 58 in.
14.	50% wool, 50% Dacron, 12-12.5 oz at 58 in.

TABLE 2 - continued

ASSIGNED SAMPLE NO.	FABRIC
15.	51% rayon, 32% wool, 12% acetate, 5% nylon
16.	43% rayon, 39% Dacron, 18% wool
17.	90% wool, 10% nylon
19.	70% wool, 30% Dynel

TABLE 3

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(End and Pick Counts; Thickness; Weight)

All tests were made on the various fabrics after they had been exposed in the standard testing atmosphere of 70° F and 65% RH for a minimum period of 24 hours. Standard or established testing procedures were followed in making the various tests.

Three end and three pick counts were made on each fabric in accordance with Spec. CCC-T-191b, Method 5050. The results reported are the means of these three counts.

Thickness measurements were made in accordance with Spec. CCC-T-191b, Method 5030, using 1.129 inches foot diameter, 10-ounce dead weight load, and 10 seconds rest period. Five tests were made on each fabric, and the means of these five tests are reported.

Weight determinations were made in accordance with Spec. CCC-T-191b, Method 5041, (weighing on an analytical balance).

SAMPLE NO.	ENDS PER INCH	PICKS PER INCH	THICKNESS (INCHES)	WEIGHT (OZS./SQ. YD.)
1	76.0	65.0	0.0180	6.51
2	54.3	50.7	0.0142	5.02
3	103.0	57.3	0.0216	8.17
4	61.3	42.0	0.0155	5.60
5	55.3	46.3	0.0146	5.11
6	51.3	42.7	0.0203	6.71
7	46.0	45.0	0.0148	5.62
8	83.0	50.0	0.0184	6.39
9	51.7	49.0	0.0162	5.61
10	85.3	47.7	0.0194	6.68
11	84.0	48.0	0.0183	6.55
12	128.3	64.0	0.0242	9.49
13	78.3	50.7	0.0168	5.56
14	86.7	56.7	0.0231	7.58
15	51.0	40.7	0.0151	6.19
16	51.7	43.0	0.0170	6.70
17	108.0	68.7	0.0240	8.55
19	48.5	45.0	0.0178	6.40

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Breaking Strength; Tear Strength)

Breaking strength tests were made in accordance with Spec. CCC-T-191b, Method 5100. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

Tear strength tests were made in accordance with Spec. CCC-T-191b. Method 5134*. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

SAMPLE NO.	BREAKING STRENGTH (LBS.)		TEAR STRENGTH (LBS.)	
	WARP	FILLING	WARP	FILLING
1	141.8	123.6	7.37	7.93
2	96.5	100.2	6.18	7.27
3	251.0	125.4	10.14	6.76
4	239.2	145.6	11.68	7.79
5	132.4	115.0	8.26	7.58
6	92.6	85.2	4.69	4.40
7	168.2	130.9	11.44	9.08
8	198.3	111.3	13.52	10.37
9	138.1	137.8	11.13	11.56
10	174.0	82.8	9.44	6.05
11	215.3	123.4	9.88	7.76
12	190.0	82.8	5.46	2.60
13	171.0	102.6	9.88	7.76
14	204.8	106.0	9.61	6.10
15	104.0	54.4	9.65	4.80
16	75.6	104.6	5.73	6.03
17	137.0	85.7	5.10	3.70
19	102.7	93.6	6.50	6.70

* In calculating the test results, an average of the minimum and maximum points was used, instead of merely reading the maximum points.

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Air Permeability)

Air permeability measurements were made in accordance with Spec. CCC-T-191b, Method 5450. Five measurements were made on each fabric. The results reported are the minimum, the maximum, and the mean of the five tests in each case.

SAMPLE NO.	AIR PERMEABILITY (CU FT AIR/SQ FT OF FABRIC/MIN)		
	MINIMUM	MAXIMUM	MEAN
1	36.2	45.2	38.4
2	89.2	97.7	93.5
3	28.0	29.5	29.1
4	206.0	222.0	209.6
5	131.0	150.0	136.4
6	28.3	30.7	29.4
7	47.1	51.9	48.9
8	88.2	96.7	92.6
9	84.9	90.8	88.1
10	59.4	68.4	64.4
11	69.3	76.3	72.9
12	12.3	13.7	13.0
13	66.6	71.8	68.8
14	36.8	40.1	38.4
15	75.1	94.5	83.2
16	55.7	58.8	57.7
17	29.9	32.6	31.5
19	33.2	37.2	35.2

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Shrinkage in Laundering and Dry-cleaning)

Fabric shrinkage in laundering tests were made in accordance with Spec. CCC-T-191b, Method 5550.

Fabric shrinkage in dry-cleaning tests were made in accordance with Spec. CCC-T-191b, Method 5580.

SAMPLE NO.	% SHRINKAGE IN LAUNDERING		% SHRINKAGE IN DRY-CLEANING	
	WARP	FILLING	WARP	FILLING
1	7.73	2.20	1.04	0.21
2	4.47	0.87	0.62	0.00
3	6.27	5.33	1.25	0.42
4	0.20	4.93	0.00	1.04
5	2.60	0.13	0.83	0.62
6	10.20	0.13 S	1.04	0.83 S
7	4.00	3.00	0.42	0.62
8	5.27	1.87	1.46	0.00
9	3.53	1.00	0.62	0.00
10	6.27	1.40	0.62	0.00
11	6.67	0.53 S	1.67	0.00
12	9.20	0.13	2.50	0.00
13	6.60	4.00	1.25	0.83
14	7.20	2.93	1.04	0.00
15	7.00	0.93	0.83	0.83
16	2.60	0.33	0.00	0.00
17	8.47	4.73	3.54	1.87
19	9.27	3.40	1.04	0.62

S - Indicates that stretching rather than shrinking occurred in laundering or dry-cleaning.

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Flex Abrasion; Surface Abrasion)

Stoll QM flex abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5300. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

Stoll QM inflated diaphragm abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5302. Five tests were made on each fabric. The results reported are the minimum, the maximum, and the mean of the five tests in each case.

SAMPLE NO.	FLEX ABRASION (NO. CYCLES TO BREAK)		SURFACE ABRASION (NO. CYCLES TO FAILURE)		
	WARP	FILLING	MINIMUM	MAXIMUM	MEAN
1	2316	2488	742	882	823
2	1174	1114	245	388	329
3	1495	1246	1739	2180	2006
4	2163	1818	2147	2906	2460
5	1799	1358	582	661	612
6	631	618	296	365	341
7	1478	1254	469	770	595
8	3171	2262	816	947	867
9	2319	2351	680	881	776
10	3867	5249	1028	1584	1243
11	869	898	837	1084	950
12	612	1154	2147	2424	2306
13	3486	2779	933	1087	986
14	1716	1960	1861	2300	2057
15	379	1175	192	269	219
16	2830	2652	486	605	546
17	1328	1316	366	467	425
19	331	344	243	299	270

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Crease Recovery)

Crease recovery tests were made in accordance with Spec. CCC-T-191b, Method 5212. Three tests were made on the face and on the back of the fabric in the warp and in the filling directions. The results reported are the means of the three tests made in each direction and on each side of the fabric.

SAMPLE NO.	% CREASE RECOVERY			
	WARP		FILLING	
	FACE	BACK	FACE	BACK
1	82	75	81	80
2	84	85	82	83
3	82	87	84	87
4	79	74	76	75
5	87	85	89	85
6	82	82	83	88
7	88	74	81	75
8	85	89	95	83
9	78	81	87	82
10	84	85	83	78
11	85	84	89	85
12	82	87	84	83
13	77	85	82	80
14	83	82	85	82
15	75	83	76	80
16	80	84	73	83
17	81	94	88	92
19	85	84	87	85

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Flame Resistance)

Flame resistance tests were made in accordance with Spec. CCC-T-191b, Method 5908. Five tests were made on each fabric. The results reported are the means of these five tests.

SAMPLE NO.	SECONDS TO IGNITE*	BURNING TIME, SECONDS/5 INCHES
1	5	20.8
2	Did not ignite	—**
3	6	24.6
4	2	22.3
5	4	17.8
6	Did not ignite	—**
7	5	21.0
8	6	19.0
9	5	18.4
10	6	21.4
11	6	22.0
12	Did not ignite	—**
13	5	20.2
14	6	25.2
15	4	50.9
16	3	38.1
17	Did not ignite	—**
19	Did not ignite	—**

* None of these fabrics ignited in the standard one-second ignition time. The ignition time was therefore extended in order to record the ease of ignition.

** Melted only at point of contact of the ignition flame without supporting combustion.

Note: In practically all instances, melting occurred in 5 - 6 seconds at the point where the standard five-eighths inch butane flame used for ignition came into contact with the fabric. On melting and forming a hole in the fabric, edge ignition occurred and the fabric in most instances supported combustion to the extent that it was slowly consumed. In some cases, the flame was self-extinguished after travelling only 2 - 3 inches up the 45° angle specimen.

This method is that specified in CS191-53 for determining the flammability hazards of clothing textiles in accordance with the Federal Flammable Fabrics Act. According to this Act and test method, all of the fabrics tested herein would be rated as Class I, Normal Flammability. Class I textiles are those that, if they ignite in one second, require four seconds or more to burn a distance of five inches.

TABLE 3 - continued

COMMERCIAL FABRICS; TEST PROCEDURES AND RESULTS
(Yarn Ply, Yarn Number, and Twist)

Yarn ply was determined in the warp and filling directions on each fabric by visual examination.

SAMPLE NO.	PLY CONSTRUCTION DETAIL	
	WARP YARN	FILLING YARN
1	Ply	Ply
2	Ply	Ply
3	Single	Single
4	Ply	Ply
5	Ply	Ply
6	Ply	Ply
7	Ply	Single
8	Ply	Ply
9	Ply	Ply
10	Ply	Ply
11	Ply	Ply
12	Ply	Ply
13	Ply	Ply
14	Ply	Ply
15	Ply	Single
16	Ply	Single
17	Ply	Ply
19	Ply	Ply

Yarn number and twist determinations in the warp and the filling were made on samples having an air permeability between 50-120 cu ft air/sq ft fabric/min and weighing between 6.5 to 7.5 ounces per square yard as required by the contract. The results for the fabrics meeting the stated conditions follow.

SAMPLE NO.	YARN NO. (WORSTED SYSTEM)*		TWIST PER INCH			
			WARP		FILLING	
	WARP	FILLING	PLY	SINGLE	PLY	SINGLE
10	2/45.0	2/45.0	22.6S	16.8Z	21.1S	19.7Z
11	2/43.6	2/45.2	25.6S	14.4Z	25.1S	20.4Z
16	2/33.4	1/17.3	14.8S	14.7Z	—	13.7Z

* The size given is for the singles yarn employed in those structures that were 2 ply.

TABLE 4

WOOL-SYNTHETIC TEST BLENDS

SAMPLE NO.	COMPOSITION
1	100% wool
2	85% wool - 15% nylon
3	70% wool - 30% nylon
4	40% wool - 60% nylon
5	85% wool - 15% Dacron
6	70% wool - 30% Dacron
7	40% wool - 60% Dacron
8	85% wool - 15% Orlon
9	70% wool - 30% Orlon
10	40% wool - 60% Orlon
11	85% wool - 15% Dynel
12	70% wool - 30% Dynel
13	40% wool - 60% Dynel

DESCRIPTIONS OF FIBERS IN BLENDS

Wool	- 64s, Australian
Nylon	- 3 den., $4\frac{1}{2}$", semi-dull; not crimp-set
Dacron	- 3 den., $4\frac{1}{2}$", semi-dull
Orlon	- 3 den., $4\frac{1}{2}$", semi-dull; Type 42
Dynel	- 3 den., *4", semi-dull

* $4\frac{1}{2}$" staple was not available.

TABLE 5

WOOL-SYNTHETIC TEST BLENDS; FINISHING PROCEDURES

Burl and Mend - Accomplished by the Buck Industrial Mending Co. of Lowell, Mass.

Fulling - Performed on a Hunter Sample Mill using single draft, minimum pressure on the rolls at the start and no weighting on the trap. The fulling soap consisted of 4 ounces of Non Pareil (medium titer) soap with 2 ounces of soda ash per gallon of fulling mix. This was added until the fabric was saturated.

Washing - Performed in the Rodney Hunt Dolly Washer using, initially, the soap in the fabric from fulling and water at 105° F. for 10 minutes. A rinse of 15 minutes at 105° F. was then given and the machine drained. The machine was then refilled with water at 105° F. to which was added 4 pails of fulling soap and 1/2 pound of Calgon. A run of 30 minutes was given, followed by a 20-minute rinse, a 10-minute Calgon rinse (1/2 pound), a 15-minute rinse (all at 105° F.), and finally a cold rinse.

Crabbing - (All except 40% wool blends). A modified crabbing operation was performed; it consisted of drawing the fabric through hot water and then winding it on a roll which was under pressure from a top roll. The fabric was then immediately rewound, under similar pressure conditions, through cold water. The operation was conducted to simulate as nearly as possible the continuous crab operation.

Extract - Centrifuge system used.

Drying - Drying was performed on the Kenyon Pin Tenter set at 180° F. and run at a speed of 8 yards per minute; in general the pins were set 1 inch wider than wet width of the fabrics. With Dynel blends the pins were set 1 inch narrower than wet widths. All drying was done with overfeeds.

The Dacron, nylon, and Orlon blends were run with a 5-1/2% overfeed. Dynel blends were run with 5-1/2% overfeed and were then re-run through the Kenyon Tenter at 235° F. with 5-1/2% overfeed at a speed of 6 yards per minute and with air circulation reduced to prevent billowing by high air velocities. The drying of samples Nos. 7, 10, and 13 was at 59-1/2", all others were at 57-1/2".

Sand and Polish - Sanding and polishing were performed on the Dacron and nylon blends with 1 run on the back and 3 on the face using an index of 5 on the Curtis and Marble machine.

Heat-Setting - Nylon and Dacron blends were heat-set on the Andrews and Goodrich unit for 1-1/4 minutes at 280° F.

TABLE 5 - continued

Steam-Brush - All fabrics were steam-brushed previous to shearing; they were given three runs on the face.

Shearing - The shearing of all fabrics was done on a Curtis and Marble Shear. All blends except those containing Dynel were given 2 runs on the back at an index of 15, and 3 runs on the face at an index of 14; the Dynel blends were given the same number of runs but the index was set at 16.

Steam-Brush- All fabrics were given 1 run on the face, except the Dynel blends which were given 3.

Rotary Press - All fabrics were put through the rotary press at an index of 14 except the Dynel blends which were not subjected to this operation.

Semi-Dacate - All fabrics were semi-decated using a 1-minute steaming followed by 1-minute of cooling by air being drawn through the fabrics in the reverse direction by the air pump.

TABLE 6

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(End and Pick Counts; Thickness; Weight)

All tests were made on the various fabrics after they had been exposed in the standard testing atmosphere at 70°F and 65% R. H. for a minimum period of 24 hours. Standard or established testing procedures were followed in making the various tests.

Three end and three pick counts were made on each fabric in accordance with Spec. CCC-T-191b, Method 5050. The results reported are the means of these three counts.

Thickness measurements were made in accordance with Spec. CCC-T-191b, Method 5030, using 1.129 inches foot diameter, 10-ounce dead weight load and 10 seconds rest period. Five tests were made on each fabric and the means of these five tests are reported.

Weight determinations were made in accordance with Spec. CCC-T-191b, Method 5041, (weighing on an analytical balance).

SAMPLE NO.	ENDS PER INCH	PICKS PER INCH	THICKNESS (INCHES)	WEIGHT (OZS./SQ. YD.)
1	86.7	50.7	0.0198	7.01
2	86.7	50.3	0.0196	7.00
3	88.3	51.3	0.0206	7.40
4	87.3	51.3	0.0194	7.13
5	88.7	50.7	0.0200	7.31
6	88.7	50.7	0.0196	7.20
7	88.3	51.0	0.0190	7.54
8	88.0	49.3	0.0184	7.13
9	87.3	50.3	0.0198	7.07
10	83.7	48.3	0.0178	6.51
11	87.0	52.7	0.0210	7.19
12	88.7	52.7	0.0218	7.53
13	86.0	53.3	0.0216	7.62

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Breaking Strength; Tear Strength)

Breaking strength tests were made in accordance with Spec. CCC-T-191b, Method 5100. Five tests were made in the warp and in the filling direction. The results reported are the means of these five tests.

Tear strength tests were made in accordance with Spec. CCC-T-191b, Method 5134*. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

SAMPLE NO.	BREAKING STRENGTH (LBS.)		TEAR STRENGTH (LBS.)			
			MEAN OF 5 HIGH POINTS		MEAN OF 5 HIGH AND 5 LOW POINTS	
	WARP	FILLING	WARP	FILLING	WARP	FILLING
1	123.3	60.3	5.56	3.76	5.10	3.30
2	154.0	74.6	8.02	6.28	6.96	5.09
3	190.2	103.5	10.32	9.04	8.51	7.27
4	254.1	150.9	15.72	12.98	12.96	10.61
5	139.3	69.9	6.96	5.28	6.63	4.33
6	145.5	74.9	9.16	7.42	8.19	5.93
7	198.6	111.2	12.10	10.40	9.90	7.91
8	107.1	52.1	4.56	3.48	4.16	3.13
9	113.5	59.6	4.26	3.74	3.85	3.12
10	135.1	70.3	4.62	4.42	3.90	3.15
11	120.3	62.8	5.40	3.54	4.65	2.96
12	130.1	69.1	5.24	3.80	4.62	3.19
13	140.9	81.4	5.36	4.52	4.50	3.49

* In calculating the test results, an average of five minimum and five maximum points was used, as well as an average of five maximum points only.

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Air Permeability)

Air permeability measurements were made in accordance with Spec. CCC-T-191b, Method 5450. Five measurements were made on each fabric. The results reported are the minimum, the maximum, and the mean of the five tests in each case.

	AIR PERMEABILITY (CU FT AIR/SQ FT OF FABRIC/MIN)		
SAMPLE NO.	MINIMUM	MAXIMUM	MEAN
1	32.0	34.0	33.1
2	34.1	38.1	35.8
3	24.3	26.7	25.5
4	20.6	26.3	23.5
5	23.1	26.7	24.6
6	23.6	24.8	24.1
7	19.7	24.8	21.7
8	26.5	29.3	27.7
9	24.8	26.5	25.3
10	32.4	34.7	33.5
11	28.5	30.7	29.9
12	23.8	26.3	25.1
13	20.3	22.3	21.7

TABLE 6 - continued

WOOL--SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Shrinkage in Laundering and Dry-Cleaning)

Fabric shrinkage in laundering tests were made in accordance with Spec. CCC-T-191b, Method 5550.

Fabric shrinkage in dry-cleaning tests were made in accordance with Spec. CCC-T-191b, Method 5580.

SAMPLE NO.	% SHRINKAGE IN LAUNDERING		% SHRINKAGE IN DRY CLEANING	
	WARP	FILLING	WARP	FILLING
1	15.13	1.13	5.42	1.25 S
2	12.87	0.60	3.75	1.25 S
3	11.80	0.53	1.87	1.25 S
4	9.13	0.87	2.29	0.42 S
5	11.87	0.53	2.50	0.83 S
6	10.13	0.13 S	1.25	0.42 S
7	6.87	0.53	0.62	0.00
8	13.67	0.47	4.17	1.46 S
9	14.00	0.67	3.33	0.83 S
10	13.73	3.20	2.71	0.62
11	10.20	1.20	1.04	0.00
12	10.93	1.60	1.25	0.00
13	10.33	7.53	1.25	0.83

S - Indicates that stretching rather than shrinking occurred in laundering or dry-cleaning.

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Flex Abrasion; Surface Abrasion)

Stoll-QM flex abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5300. Five tests were made in the warp and the filling directions. The results reported are the means of these five tests.

Stoll QM inflated diaphragm abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5302. Five tests were made on each fabric. The results reported are the minimum, the maximum, and the mean of the five tests in each case.

SAMPLE NO.	FLEX ABRASION (NO. CYCLES TO BREAK)		SURFACE ABRASION (NO. CYCLES TO FAILURE)		
	WARP	FILLING	MINIMUM	MAXIMUM	MEAN
1	1277	1575	508	591	551
2	3107	2929	622	802	701
3	3595	4053	1041	1271	1146
4	3444	5144	1109	1998	1521
5	2828	2154	1024	1948	1289
6	3757	2944	2083	2258	2199
7	4650	5450	3776	4561	4089
8	1294	1141	535	673	622
9	993	1144	672	937	833
10	327	516	907	1136	967
11	1165	1115	471	558	507
12	784	1027	589	645	610
13	457	785	561	743	673

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Crease Recovery)

Crease recovery tests were made in accordance with Spec. CCC-T-191b, Method 5212. Three tests were made on the face and on the back of the fabric in the warp and in the filling directions. The results reported are the means of the three tests made in each direction and on each side of the fabric.

	% CREASE RECOVERY			
	WARP		FILLING	
SAMPLE NO.	FACE	BACK	FACE	BACK
1	93	89	87	97
2	92	91	89	95
3	88	85	87	90
4	85	78	83	88
5	93	89	86	93
6	91	86	89	90
7	92	91	87	93
8	95	86	89	91
9	91	87	88	90
10	90	82	87	89
11	91	89	89	95
12	91	91	90	91
13	92	83	87	92

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Flame Resistance)

Flame resistance tests were made in accordance with Specification CCC-T-191b, Method 5902, Flame Resistance of Cloth, Vertical. Five Tests were made warpwise and fillingwise. The results reported below are the means of the combined warp and filling.

	SAMPLE NO.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Max. Flame Time (seconds)	50	42	85	50	27	47	24	32	27	20	31	48	44
Max. Glow Time (seconds)	2	0	0	0	0	0	0	0	0	0	0	0	0
Max. Char Length (inches)	0	0	0	1.50	1.50	1.78	1.25	0	0	0	5.50	7.00	6.00
Ave. Flame Time (seconds)	29.5	34.8	39.8	34.	23.6	27.6	8.3	25.4	21.9	18.8	27.6	35.	37.5
Ave. Glow Time (seconds)	.7	0	0	0	0	0	0	0	0	0	0	0	0
Ave. Char Length (inches)	0	0	0	.78	.33	.33	.83	0	0	0	3.75	2.53	.80

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Pilling)

The test procedure followed was that in CCC-T-191b, Method 5310T, Appearance-Retention of Cloth, Pilling and Surface Wear (Press). Each fabric was tested using a 15-minute run under a pressure of 1.6 psi.

The rating shown is based on the number of pills found.

SAMPLE NO.	PILL RATING
1	None
2	None
3	None
4	None
5	None
6	None
7	None
8	None
9	None
10	None
11	None
12	None
13	None

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS: TEST PROCEDURES AND RESULTS
(Sewability; Strength of Seam Method)

Sewability tests, Strength of Seam Method, were made in accordance with Spec. CCC-T-191b, Method 5110. The results reported are the means of 10 tests.

SAMPLE NO.	% SEAM EFFICIENCY
1	70
2	75
3	69
4	57
5	64
6	77
7	63
8	84
9	78
10	54
11	77
12	64
13	58

TABLE 6 - continued

WOOL-SYNTHETIC TEST BLENDS; TEST PROCEDURES AND RESULTS
(Sewability Yarn Severance Method)

Sewability tests, Yarn Severance Method, were made in accordance with Spec. CCC-T-191b, Method 5400. The results reported are the means of five tests. The filling yarn severance is reported to the nearest 0.1 per cent and the warp yarn severance to the nearest 1.0 yarn.

SAMPLE NO.	WARP (NO. OF YARNS SEVERED)	FILLING (% YARNS SEVERED)
1	1	2.0
2	1	10.4
3	3	2.9
4	4	1.9
5	3	6.7
6	2	7.8
7	0	6.5
8	1	7.6
9	2	3.8
10	6	5.7
11	0	5.7
12	1	10.1
13	2	7.6

TABLE 7

FOUR WOOL-DYNEL BLEND SECTIONS; FINISHING PROCEDURE

General: Four sample ends, totaling 17 yards off-loom, were finished. Yarns were the same in all 4 pieces. Blend was 30% Dynel natural staple and 70% wool. Construction was identical in the 4 pieces (Sections A, B, C, and D), except that picks were varied from 36-42 in increments of 2.

Off-Loom Fabric:

Width 60.5 inches O. A.
Wt. Ave. of 4 = 10.4 oz.

Washing: Dolly type washer - Regular worsted scour.

After washing dimensions were taken only after extracting.

Length - Yd. Mark was sewn in on both ends of fabric.

Vacuum extracting and scutching.

Low pick fabric (Section A)	Length - 36 Width - 57-7/8
High pick fabric (Section D)	Length - 36 Width - 56-1/8

Drying: A Kenyon 5 bank cloth dryer was used. Temperature by thermometer on center of left side of unit held 250-255° F. throughout the drying time. The fabric was dried running the high pick count fabric in first. Total treatment time was 11-1/2 minutes with cloth chain running at lowest speed.

Tenter was set at 57-1/2 inches for all 4 fabrics which, of course, were run as one piece.

No overfeed was available on this unit, but cloth was hand-fed to tenter with complete relaxation of the warp.

To reduce fan pressure the top fan was shut off while fabric was on the top 2 banks. This fan was then started and the bottom fan stopped during passage of the cloth over the bottom 3 banks.

The dryer was not equipped with automatic temperature regulators.

Dimensions after drying:

Low pick fabric (Section A): Length = 36-1/2 Width = 58

High pick fabric (Section D): Length = 37-1/2 Width = 58-1/4

Shearing: A modern 3-blade shear was used. Fabric received one pass with first blade shearing the back and next two blades shearing the face.

Dimensions after shearing:

Low pick fabric (Section A): Length = 36-1/2 Width = 58

High pick fabric (Section D): Length = 37-1/4 Width = 58

Semi-decating: Parks Woolson machine - about 40 in. cylinder.
Steam pressure at mantle, closed valve = 60#.
Steam pressure at mantle, during steaming of fabric = 15#.

Cloth fed with relaxed warp and no roll pressure on winding. Steamed for 1-1/2 min. after steam had come through roll. Fabric was removed hot without any pumping and allowed to cool on a cloth roll. (Fabric was removed hot in order to obtain a softer hand). It is doubtful that this treatment of removing fabric hot has any effect on the Dynel constituent. It is known that pumping after steaming "firms up" the wool; thus, by steaming only a softer fabric is produced.

Finished Dimensions:

Low pick fabric (Section A): Length = 36-1/4 Width = 57-1/2

High pick fabric (Section D): Length = 36-1/2 Width = 57-1/2

TABLE 8

FOUR WOOL-DYNEL BLEND SECTIONS; TEST PROCEDURES AND RESULTS
(End and Pick Counts; Weight and Air Permeability Determinations)

Three end and pick counts were made on each section. The results reported are the means of these three counts.

Weight determinations were made by weighing 72 square inches on an analytical balance.

SECTION	ENDS PER INCH	PICKS PER INCH	WEIGHT (OZ/SQ. YD.)
A	47.0	41.3	6.78
B	47.0	42.7	6.88
C	47.0	46.0	7.17
D	47.0	46.7	7.20

Air permeability tests were made using the National Bureau of Standard instruments, operating at a pressure drop of 0.5 inches of water across the surface of the fabric. The results reported are the means of five tests.

SECTION	AIR PERMEABILITY (CU FT AIR/SQ FT OF FABRIC/MIN)
A	62.6
B	53.3
C	38.3
D	41.5

TABLE 9

WOOL–DYNEL BLEND SECTIONS A AND B; TEST PROCEDURES AND RESULTS
(Thickness; Breaking Strength; Tear Strength)

Thickness measurements were made in accordance with Spec. CCC–T–191b, Method 5030, using 1.129 inches foot diameter, 10–ounce dead weight load, and 10 seconds rest period. Three tests made on Section A are reported.

THICKNESS (INCHES)
0.0230
0.0230
0.0235

Breaking strength tests were made in accordance with Spec. CCC–T–191b, Method 5100. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

Tear strength tests were made in accordance with Spec. CCC–T–191b, Method 5134*. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

	BREAKING STRENGTH (LBS.)		TEAR STRENGTH (LBS.)			
			MEAN OF 5 HIGH POINTS		MEAN OF 5 HIGH AND 5 LOW POINTS	
SECTION	WARP	FILLING	WARP	FILLING	WARP	FILLING
A	97.7	81.6	7.76	6.00	6.38	5.10
B	101.1	86.4	7.44	6.34	6.30	5.22

* In calculating the test results, an average of five minimum and five maximum points was used, as well as an average of five maximum points only (Method 5134 specifies the latter method).

TABLE 9 - continued

WOOL-DYNEL BLEND SECTIONS A AND B; TEST PROCEDURES AND RESULTS
(Shrinkage in Laundering and Dry-Cleaning)

Fabric shrinkage in laundering tests were made in accordance with Spec. CCC-T-191b, Method 5550.

Fabric shrinkage in dry-cleaning tests were made in accordance with Spec. CCC-T-191b, Method 5580.

SECTION	% SHRINKAGE IN LAUNDERING		% SHRINKAGE IN DRY-CLEANING	
	WARP	FILLING	WARP	FILLING
A	8.73	7.73	1.46	0.83
B	11.93	7.60	2.08	0.42

TABLE 9 - continued

WOOL-DYNEL BLEND SECTIONS A AND B; TEST PROCEDURES AND RESULTS
(Flex Abrasion; Surface Abrasion; Crease Recovery; Pilling)

Stoll QM flex abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5300. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

Stoll QM inflated diaphragm abrasion tests were made in accordance with Spec. CCC-T-191b, Method 5302. Five tests were made on each fabric. The results reported are the minimum, the maximum, and the mean of the five tests in each case.

	FLEX ABRASION (NO. OF CYCLES TO BREAK)		SURFACE ABRASION (NO. OF CYCLES TO FAILURE)		
SECTION	WARP	FILLING	MINIMUM	MAXIMUM	MEAN
A	793	840	405	665	502
B	762	764	377	494	422

Crease recovery tests were made in accordance with Spec. CCC-T-191b, Method 5212. Three tests were made on the face and on the back of the fabric in the warp and in the filling directions. The results reported are the means of the three tests made in each direction and on each side of the fabric.

	% CREASE RECOVERY			
	WARP		FILLING	
SECTION	FACE	BACK	FACE	BACK
A	92	90	93	89
B	88	96	92	92

Pilling tests were made in accordance with Spec. CCC-T-191b, Method 5310T, Appearance-Retention of Cloth, Pilling and Surface Wear (Press). Each fabric was tested using a 15-minute run under a pressure of 1.6 psi. The rating shown is based on the number of pills found.

SECTION	PILL RATING
A	None
B	None

TABLE 9 - continued

WOOL-DYNEL BLEND SECTIONS A AND B; TEST PROCEDURES AND RESULTS
(Flame Resistance; Yarn Number; Twist)

Flame resistance tests were made in accordance with Spec. CCC-T-191b, Method 5902, Flame Resistance of Cloth; Vertical. Five tests were made warpwise and fillingwise.

	SECTION A		SECTION B	
	WARP	FILLING	WARP	FILLING
Max. Flame Time (seconds)	32	34	31	32
Max. Glow Time (seconds)	0	0	0	0
Max. Char Length (inches)	1.2	1.0	1.0	1.1
Ave. Flame Time (seconds)	30	27	28	26
Ave. Glow Time (seconds)	0	0	0	0
Ave. Char Length (inches)	0.7	0.6	0.5	0.7

Twist per inch determinations were made in accordance with Spec. CCC-T-191b, Method 4054 for the ply yarns, and Method 4052 for the single yarns. Five tests were made in the warp and in the filling directions. The results reported are the means of these five tests.

Yarn number was determined by weighing 3 yards of yarn on an analytical balance.

	YARN NO. (WORSTED SYSTEM)		TWIST PER INCH			
			WARP		FILLING	
SECTION	WARP	FILLING	PLY	SINGLE	PLY	SINGLE
A	2/32.0	2/31.5	17.0S	15.4Z	13.6S	14.4Z
B	2/30.4	2/31.3	16.0S	15.2Z	16.7S	15.1Z

TABLE 10

WOOL DYE FORMULA FOR SAGE GREEN 527

Irgalon Olive BGL	8-1/8 oz.
Irgalon Yellow GL	7/8 oz.
Alizarine Cyanine Green CG Ex.	15/16 oz.
Pontachrome Grey GL	1/2 oz.
Chrome	1/4 oz.
Acetate Ammonia	1 lb.
Glaubers Salts	2 lbs.
Approximate Dyeing Time	2 hrs.

Color Exhausted with Acetic Acid

NOTE: It is not to be construed that formulae other than the above cannot perform equally satisfactorily. Also, the selection of this particular dye formula for producing the fabric required in this project does not imply approval for Air Force use nor does it represent a standard for future procurement.

TABLE 11

DYNEL DYE FORMULA AND PROCEDURE FOR SAGE GREEN 527

SHADE:	Sage Green 527		
EQUIPMENT:	Abbott Top Kettle		
MATERIAL:	Dynel - 3 denier - 4-1/2" Converter Top		
ASSISTANTS:	All percentages are based on the material.		
	Wet Out:	D. C. Antifoam A. Emulsion	0.1%
	Dyeing:	Igepon T-73	3.0%
		DSP-112	2.0%
DYES:		Vialon Fast Olive B	1.0%
		Irgalan Orange RL	0.12%

DYEING AND FINISHING PROCEDURE Ratio 15:1

1. Load top into machine.
2. Add DC Antifoam A Emulsion to the first water that is added to the top.
3. Add 1/4 of the Igepon T-73 to bath and use 1/2 to disperse Dysist 112 in 200° F. Water. Add DSP-112 emulsion to the dyebath at 120° F.
4. Dissolve dyes with 1/4 Igepon T-73 and add to bath at 120° F.
5. Boil 1-1/2 hours and then cool slowly.
6. Rinse at 165° F. for 20 minutes.
7. Use 120° F. water for the final rinse.
8. Dry top at 250° F. to develop full luster.

NOTE: It is not to be construed that formulae other than the above cannot perform equally satisfactorily. Also, the selection of this particular dye formula for producing the fabric required in this project does not imply approval for Air Force use nor does it represent a standard for future procurement.

TABLE 12

COLORFASTNESS TESTS ON 70% WOOL-30% DYNEL FABRIC DYED SAGE GREEN 527

The test procedures (CCC-T-191b) used and the results obtained follow:

A. Colorfastness to Light, Method 5660.
No standard sample of the specimen was available; consequently, exposure time was 40 Standard Fading Hours.

Results: Appreciable but not objectionable change in color in 40 hours. Fair.

B. Colorfastness to Laundering, Method 5614.
Results: No appreciable change in color, no staining of the color transfer cloth. Good.

Pressing of the specimen with an iron at 275 - 300° F. causing a slight fusing of the Dynel resulting in a slight stiffening of the fabric.

C. Colorfastness to Perspiration, Method 5682.
Results: No appreciable change in color, no staining of the color transfer cloth. Good.

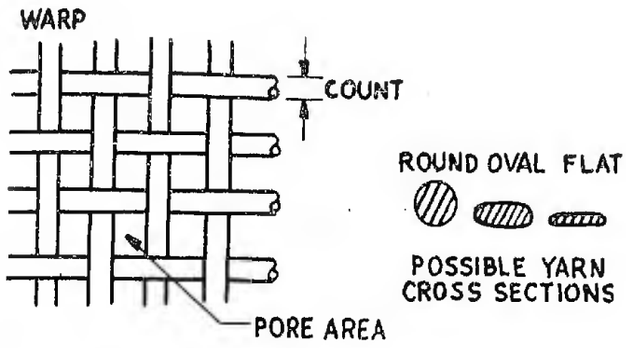

FIGURE 1 - PLAIN WEAVE-PLAN VIEW

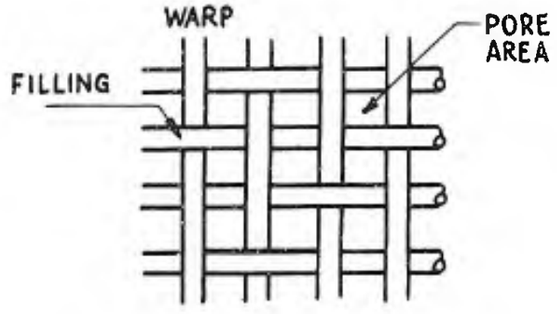

FIGURE 2 - TWILL WEAVE (2/1)-PLAN VIEW

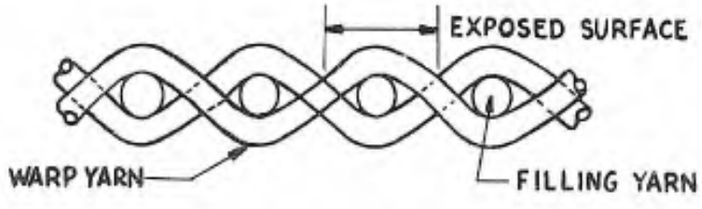

FIGURE 3 - PLAIN WEAVE-CROSS SECTION

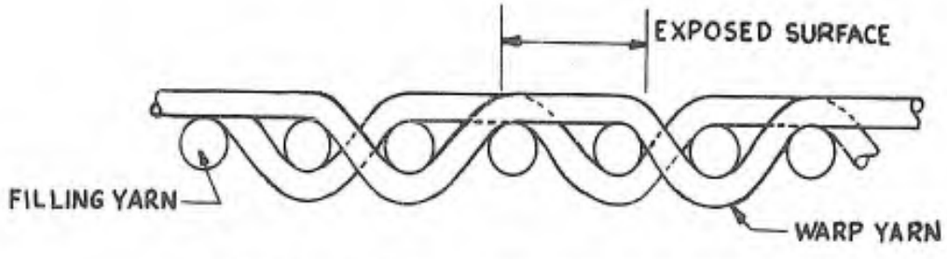

FIGURE 4 - TWILL WEAVE (2/1)-CROSS SECTION

FIGURE 5 - YARN BLEND

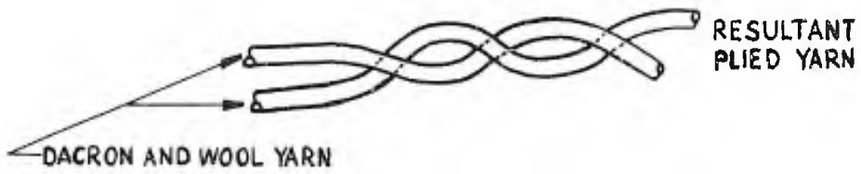

FIGURE 6 - FIBER BLEND

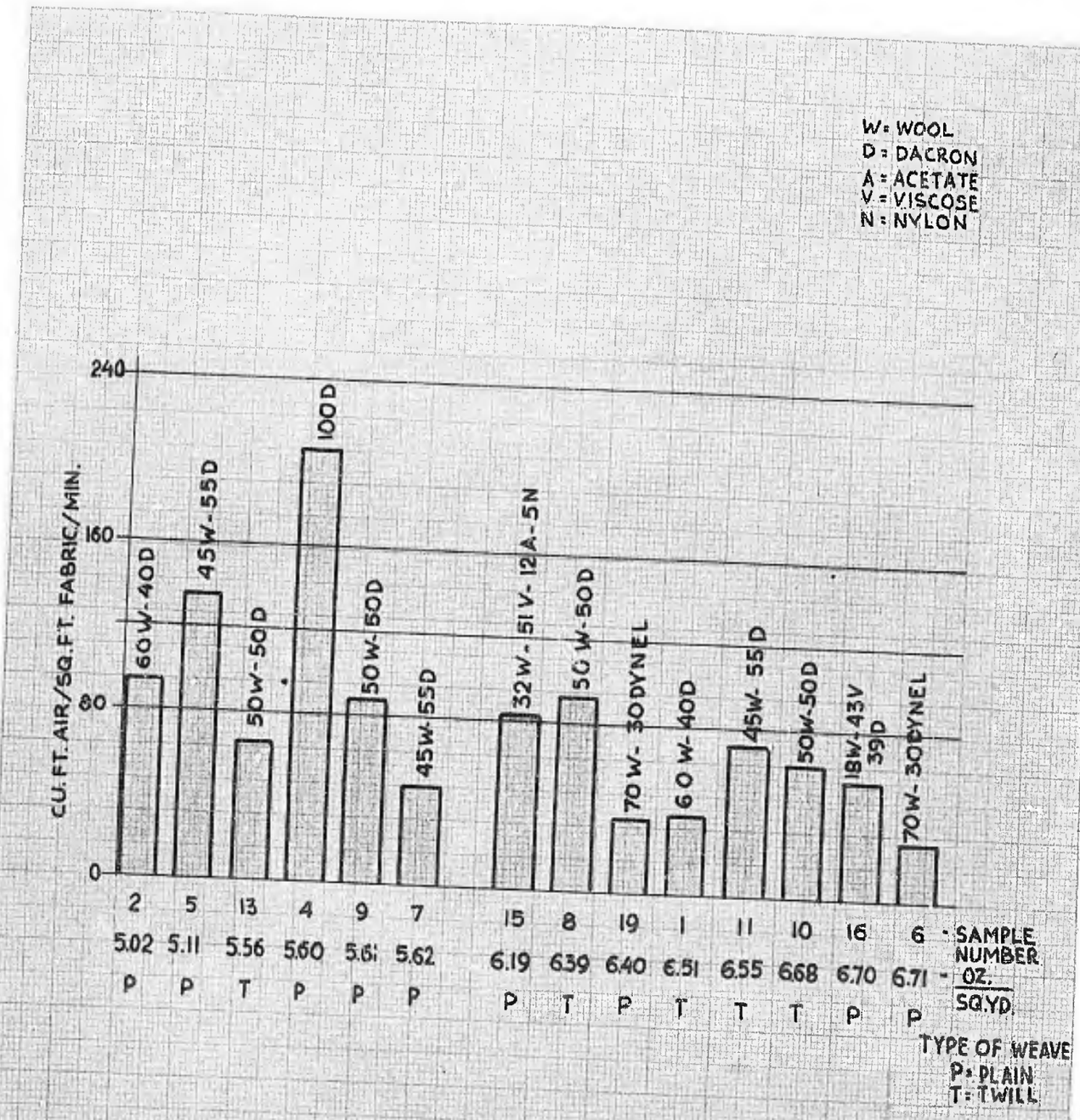

FIGURE 7 - AIR PERMEABILITY (COMMERCIAL FABRICS)

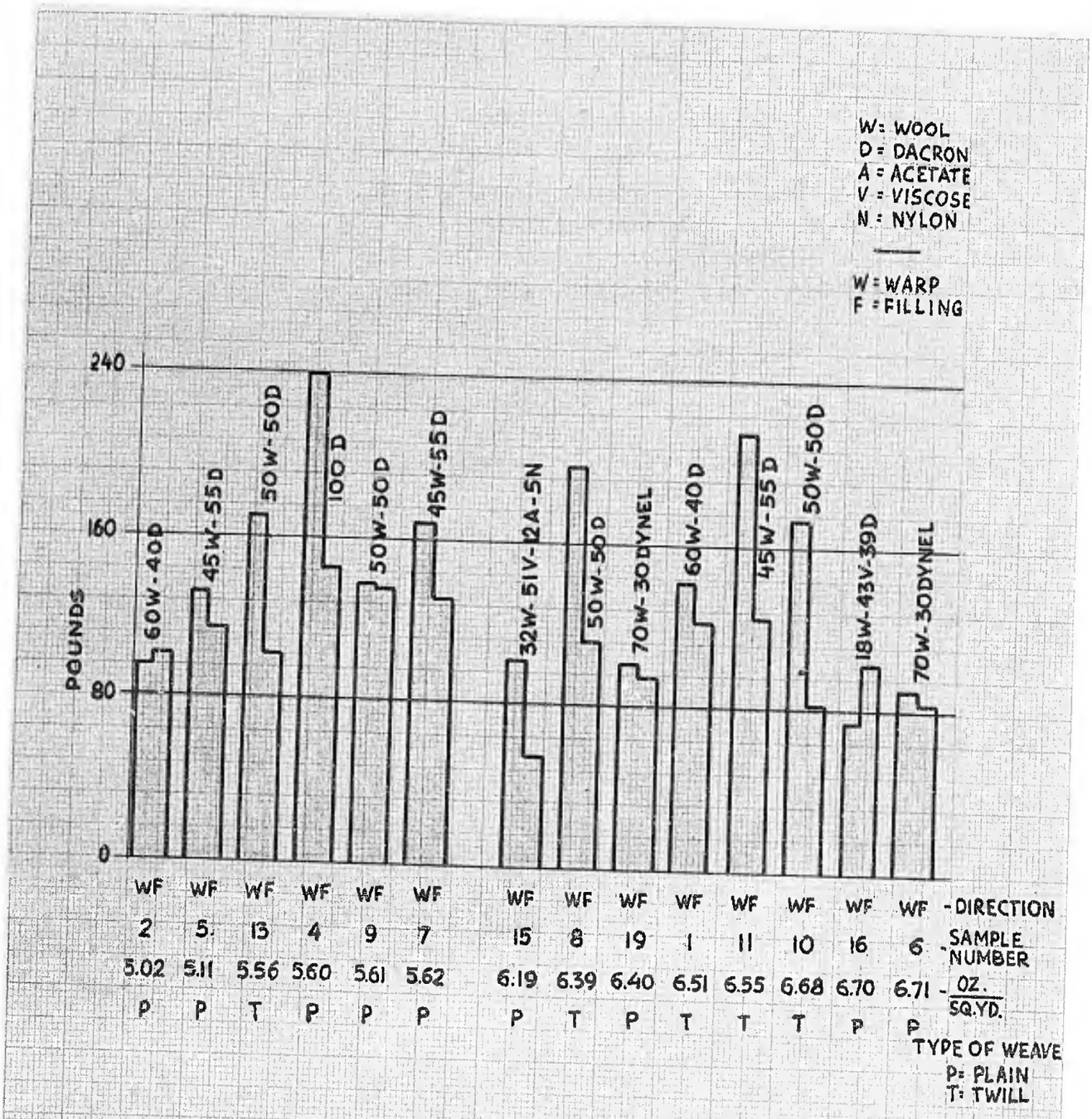

FIGURE 8 - BREAKING STRENGTH (COMMERCIAL FABRICS)

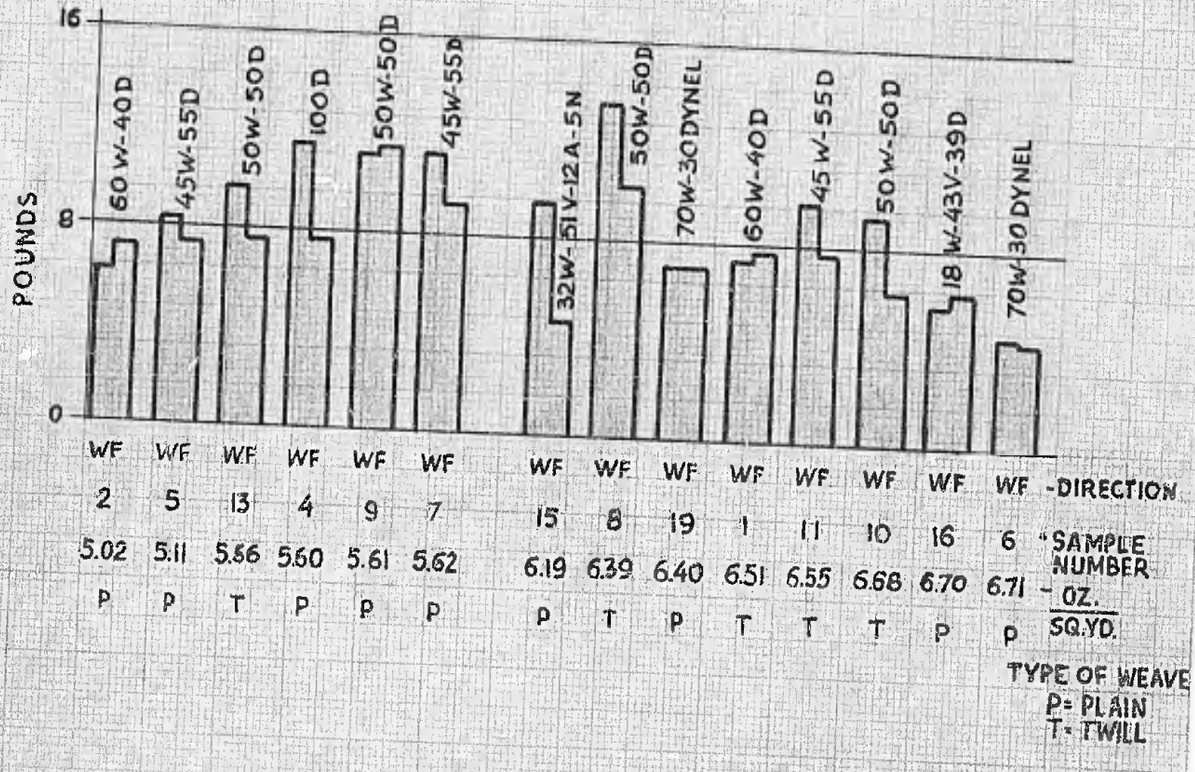

FIGURE 9 - TEAR STRENGTH (COMMERCIAL FABRICS)

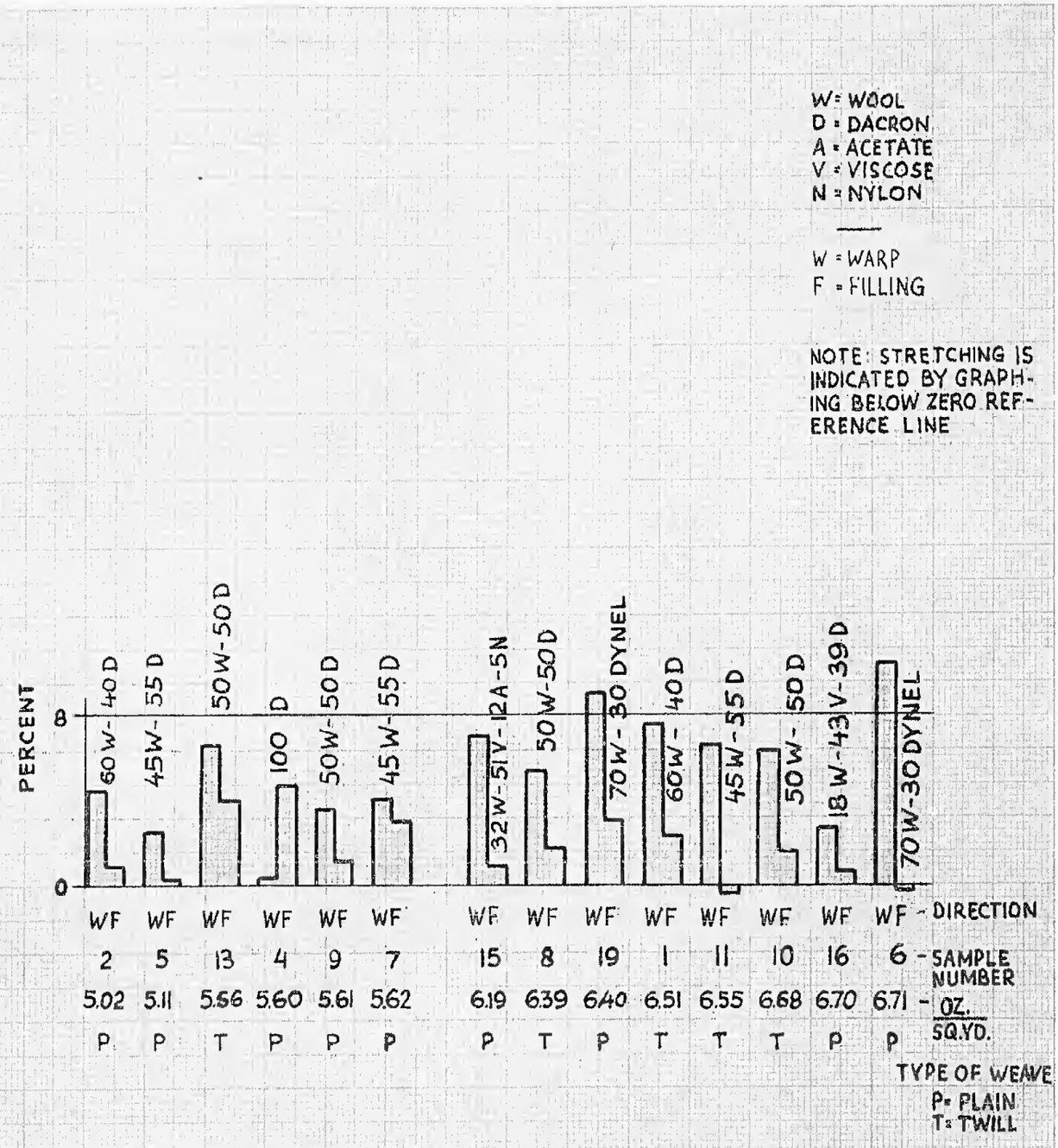

FIGURE 10 - SHRINKAGE IN LAUNDERING (COMMERCIAL FABRICS)

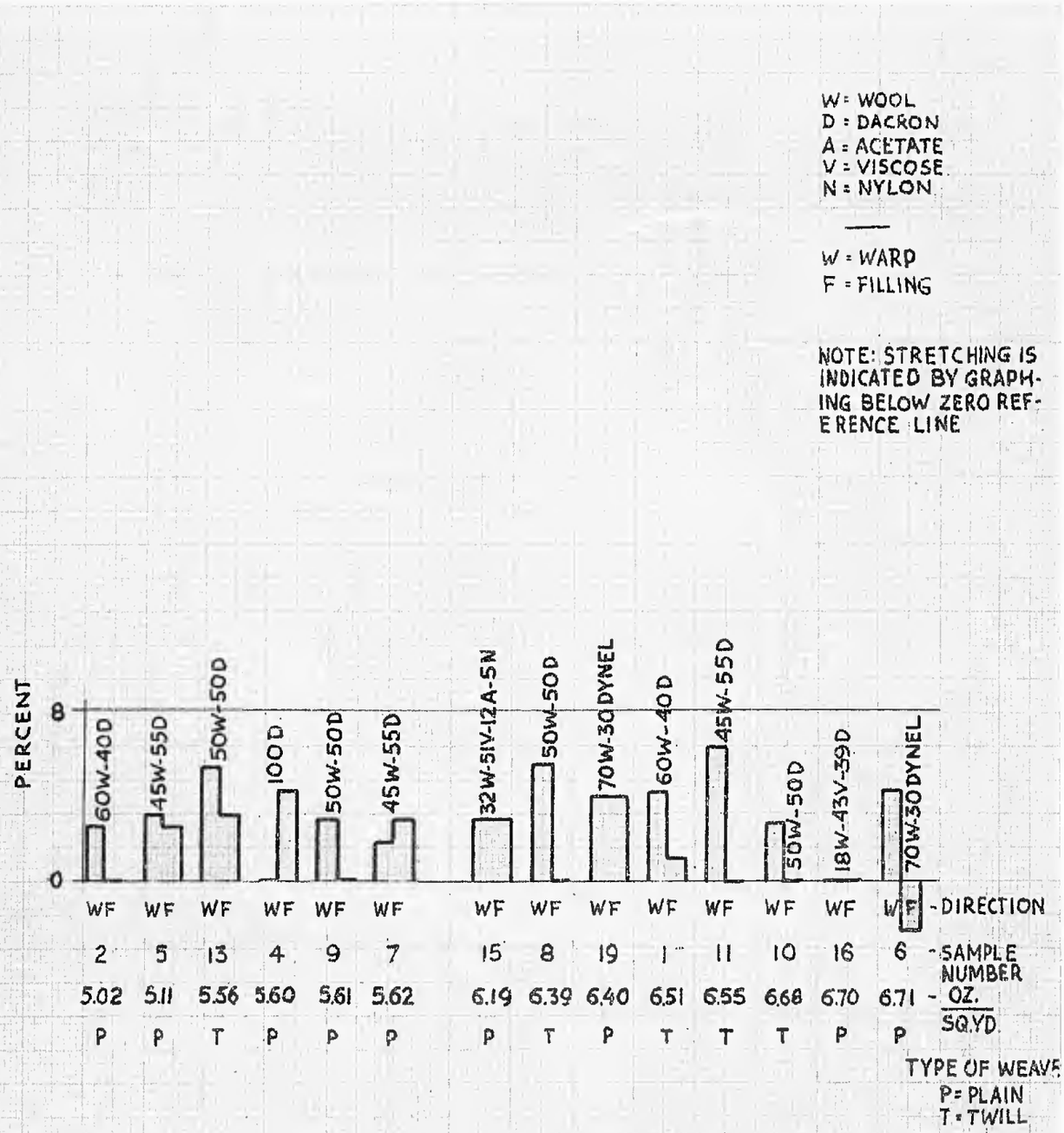

FIGURE 11 - SHRINKAGE IN DRY-CLEANING (COMMERCIAL FABRICS)

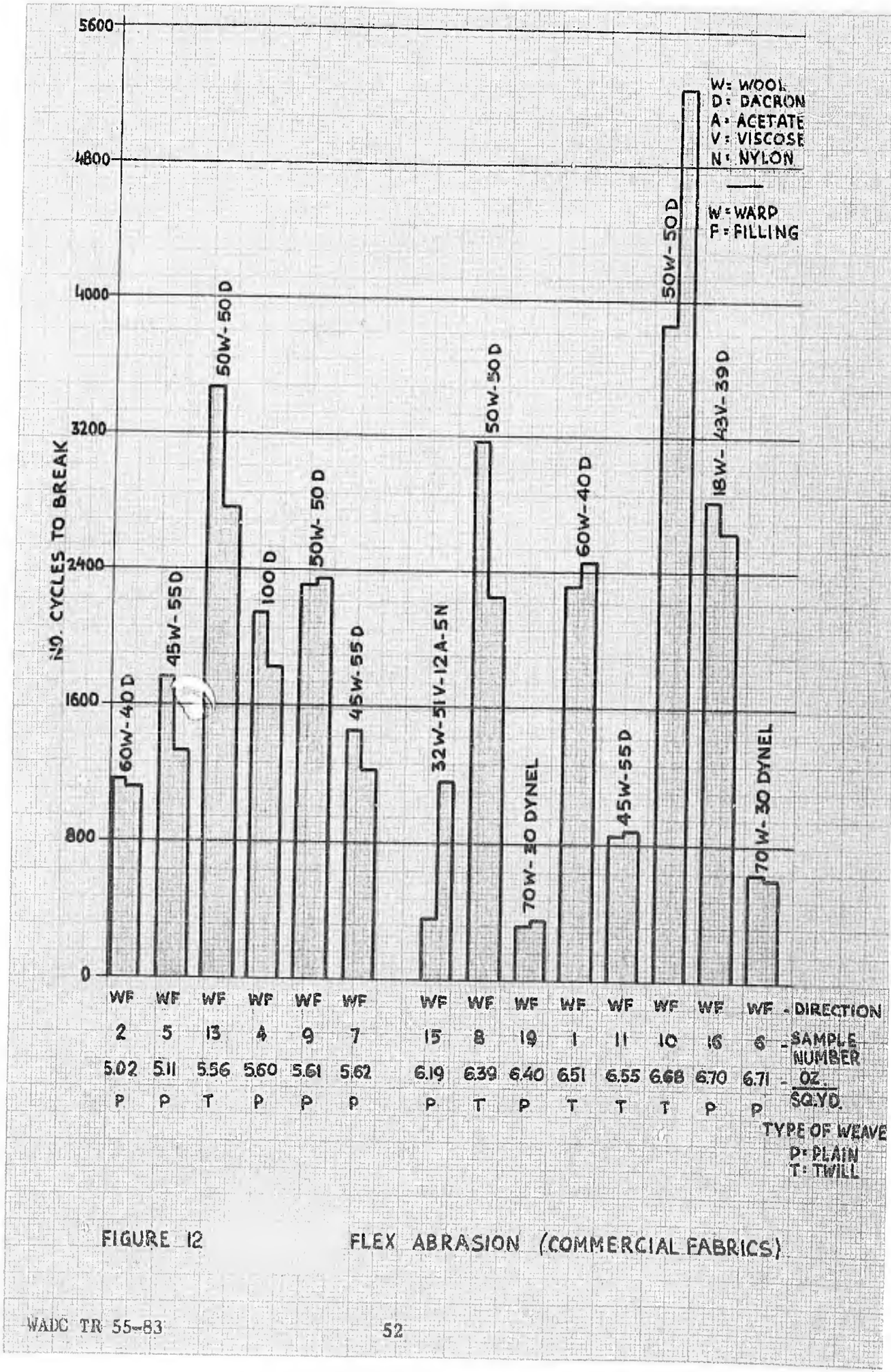

FIGURE 12 FLEX ABRASION (COMMERCIAL FABRICS)

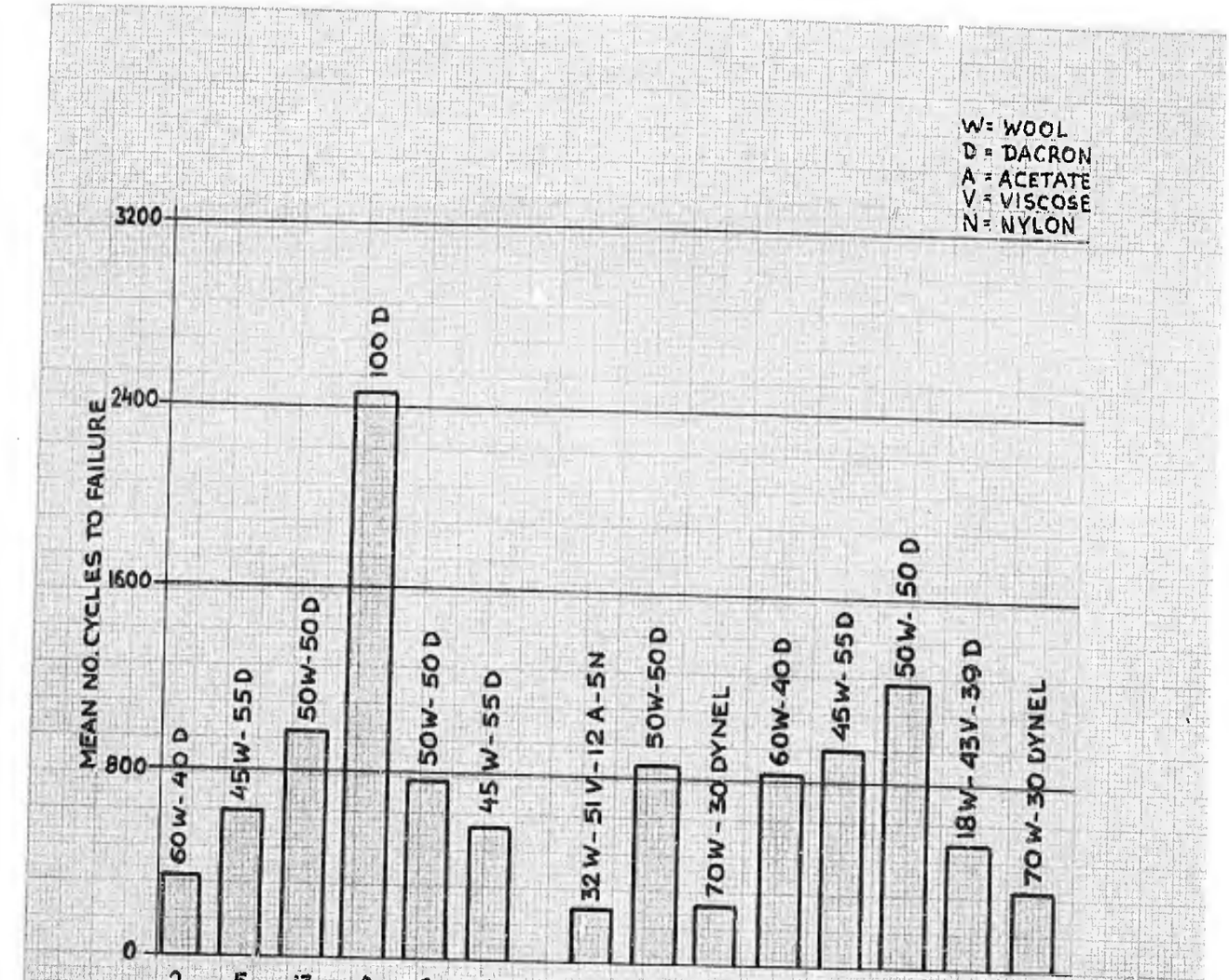

FIGURE 13 SURFACE ABRASION (COMMERCIAL FABRICS)

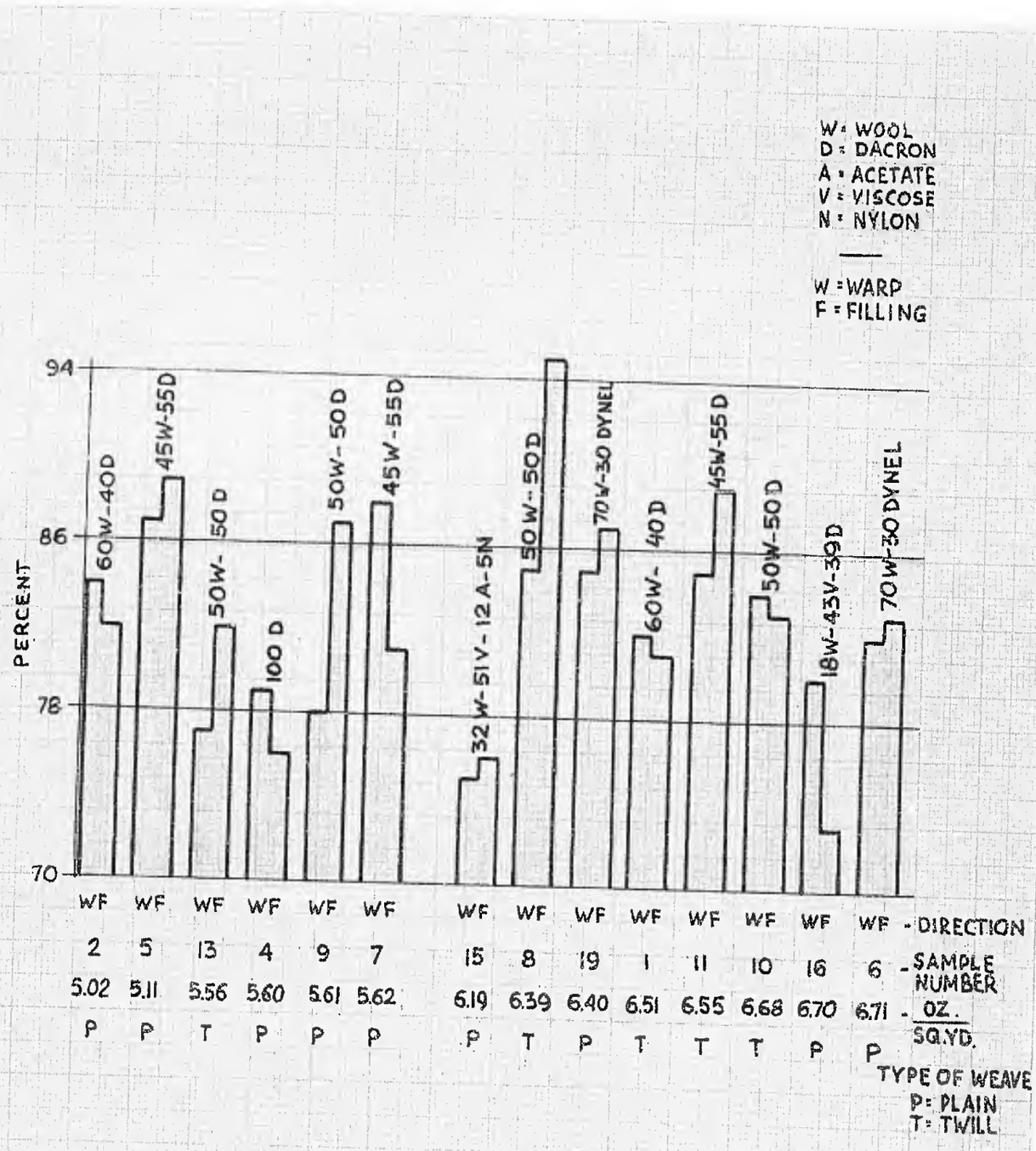

FIGURE 14 - CREASE RECOVERY (COMMERCIAL FABRICS)

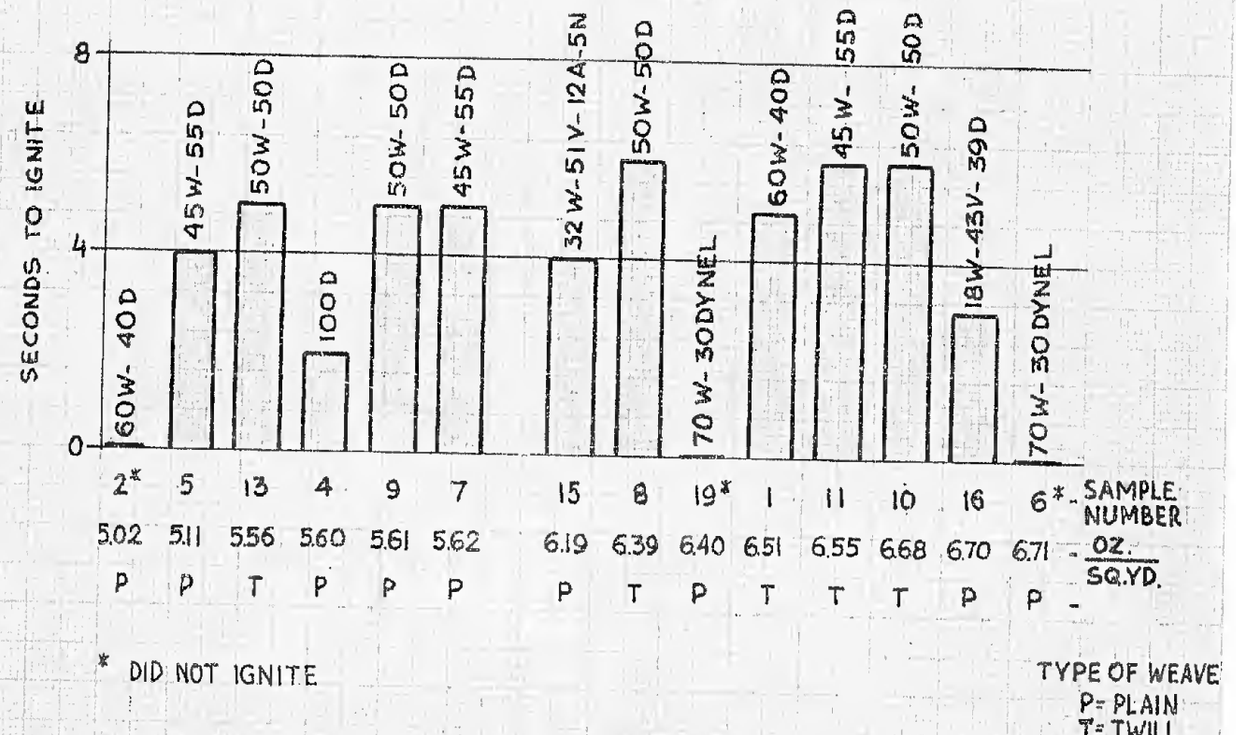

FIGURE 15 - FLAME RESISTANCE (COMMERCIAL FABRICS)

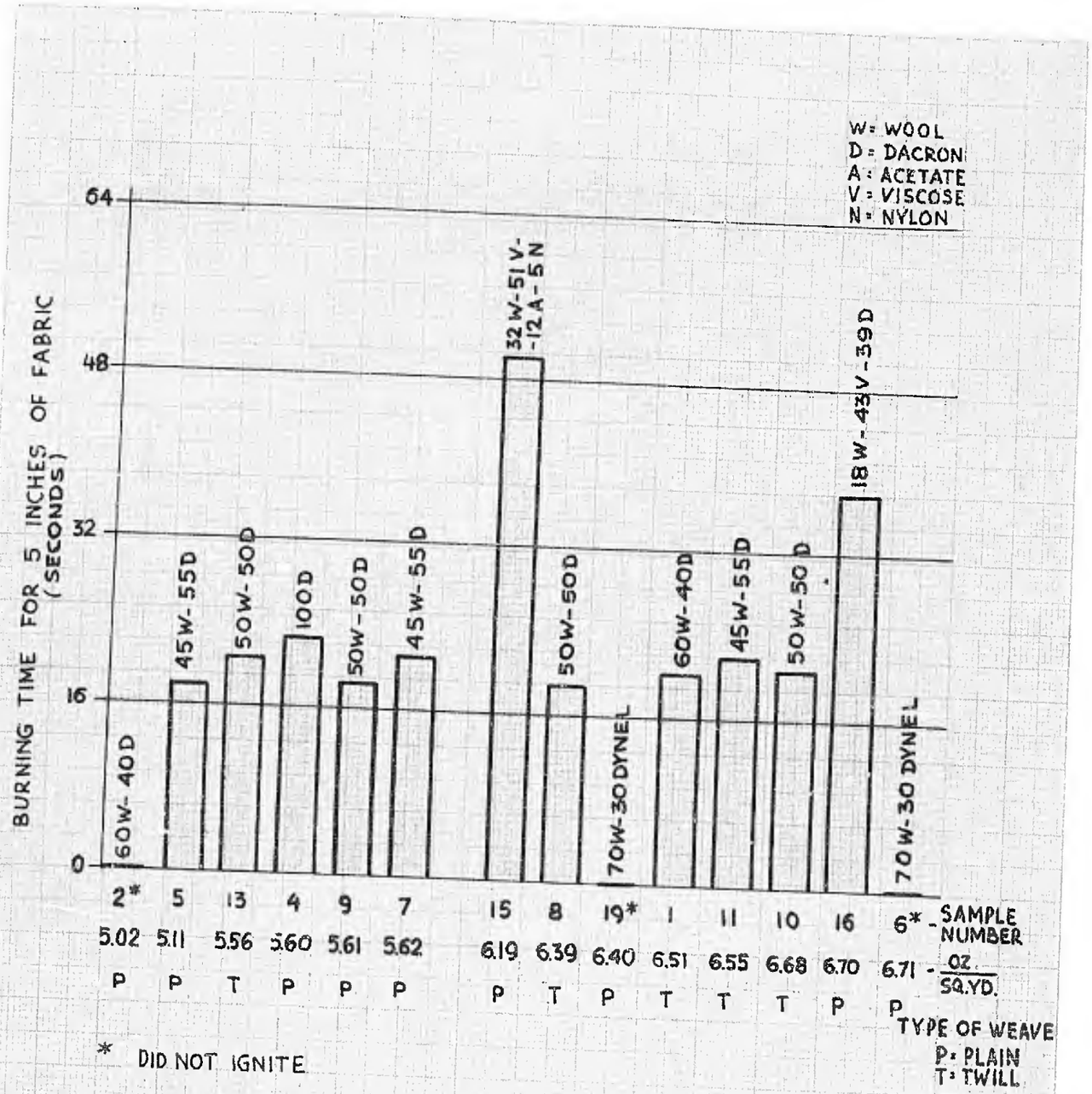

FIGURE 16- BURNING TIME (COMMERCIAL FABRICS)

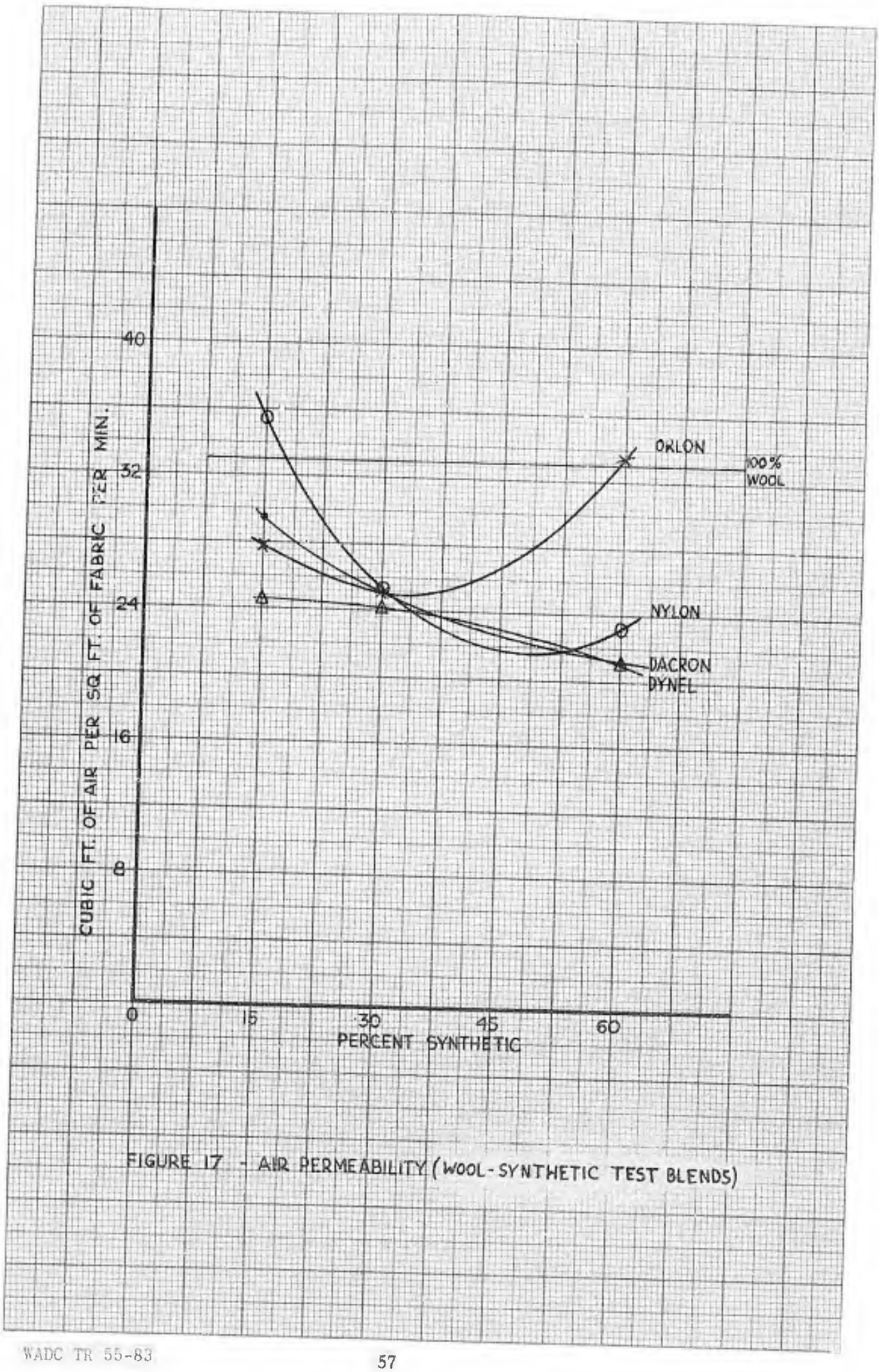

FIGURE 17 - AIR PERMEABILITY (WOOL-SYNTHETIC TEST BLENDS)

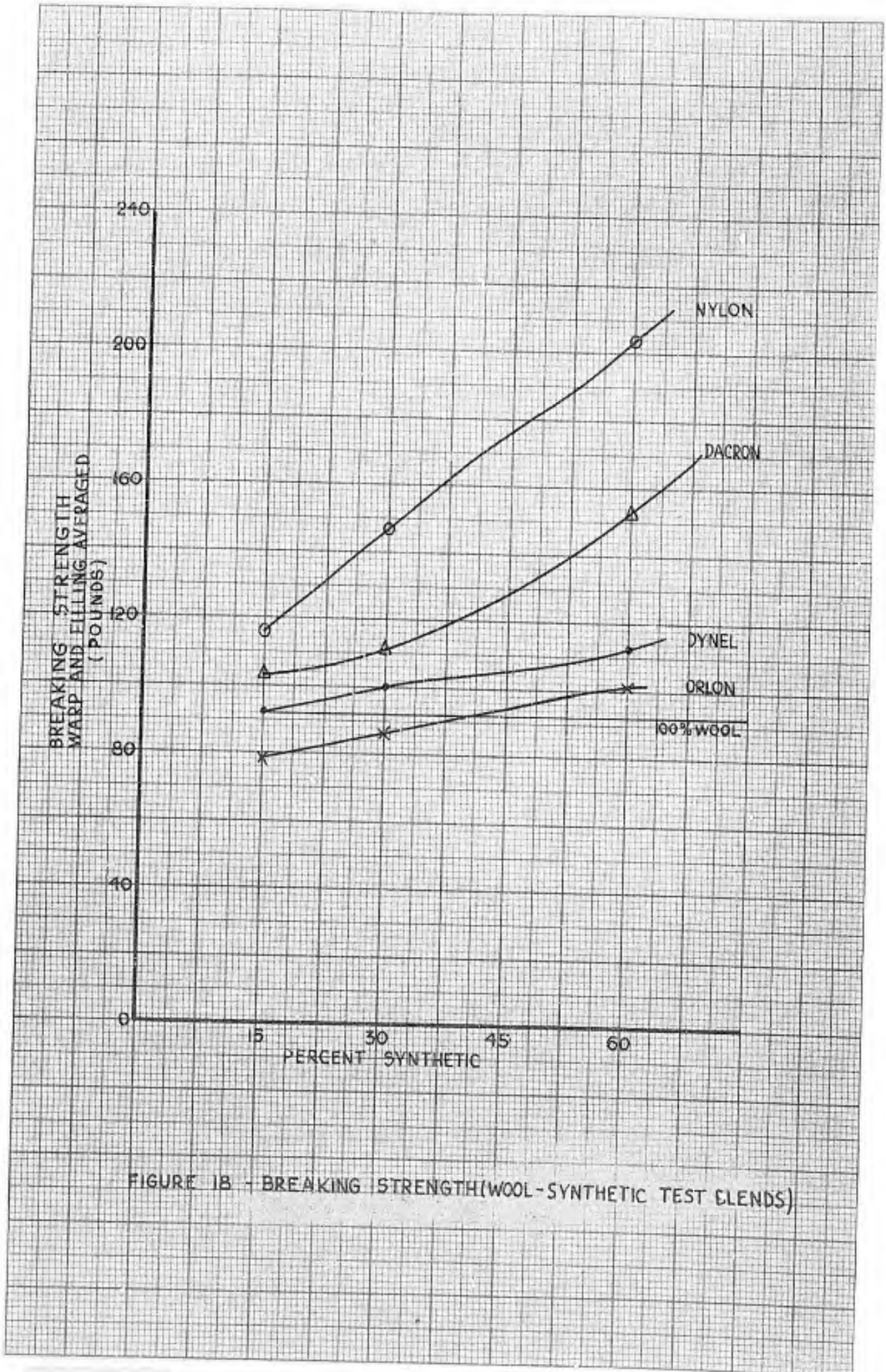

FIGURE 18 - BREAKING STRENGTH (WOOL-SYNTHETIC TEST BLENDS)

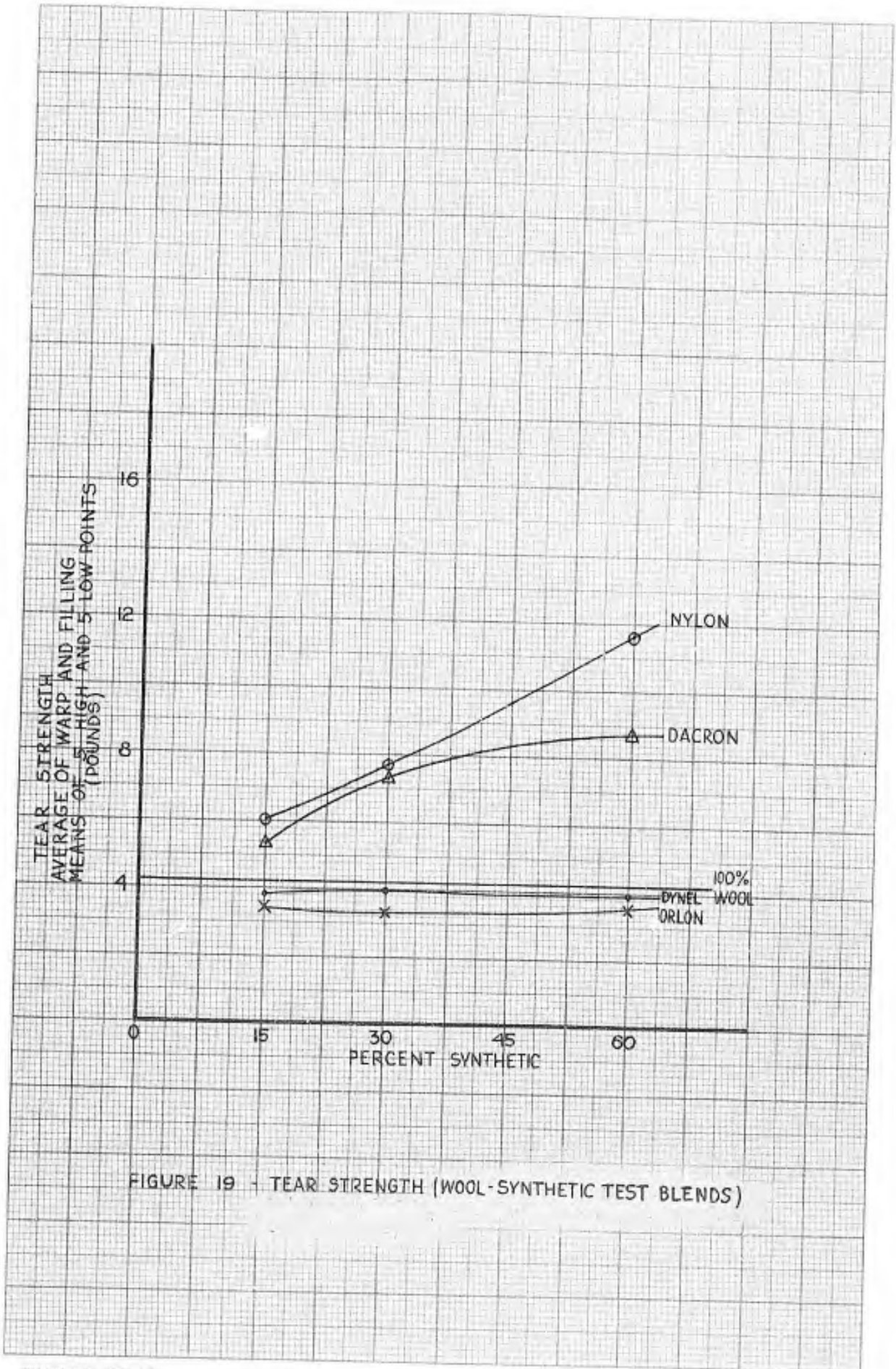

FIGURE 19 - TEAR STRENGTH (WOOL-SYNTHETIC TEST BLENDS)

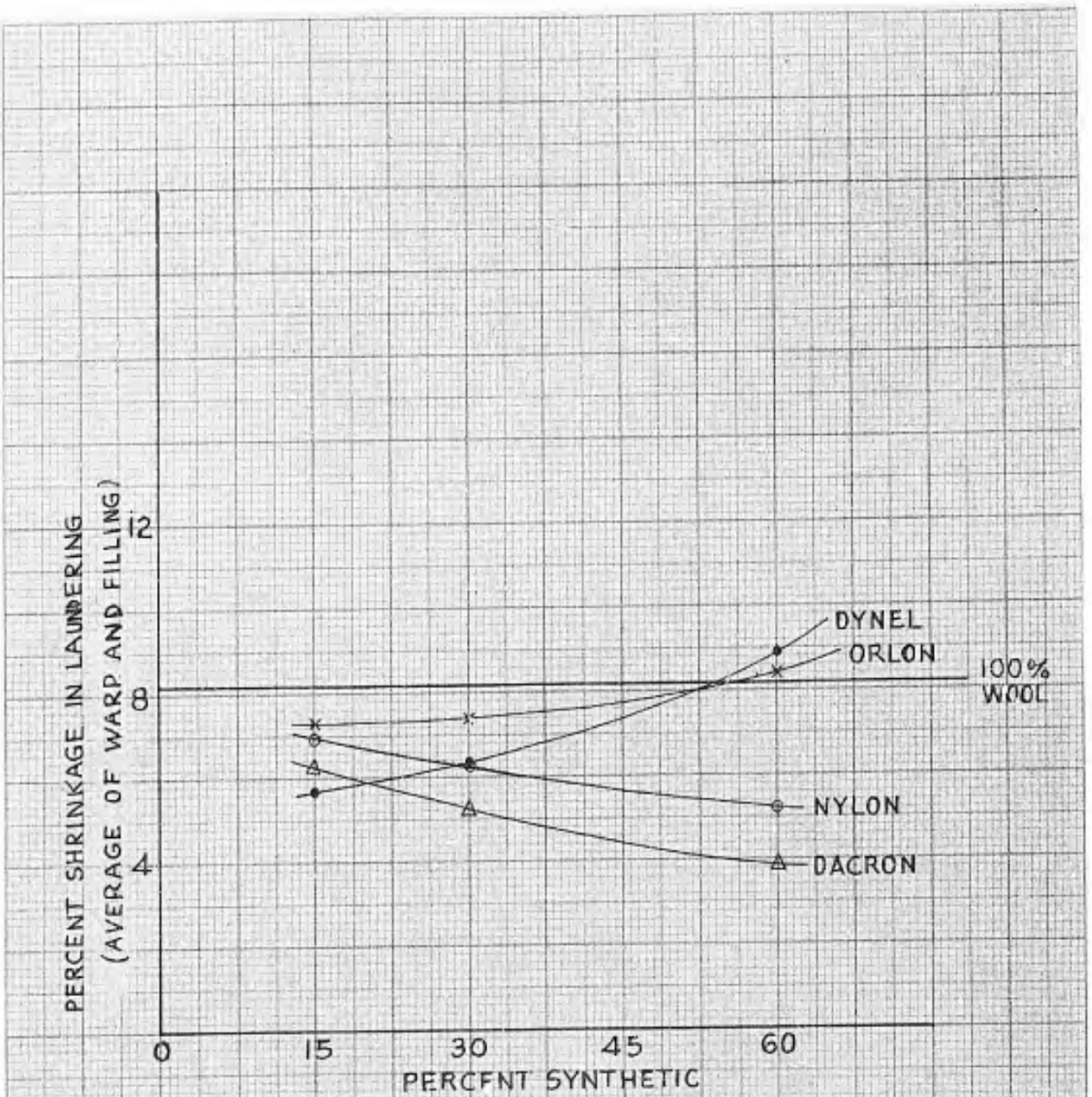

FIGURE 20- SHRINKAGE IN LAUNDERING (WOOL-SYNTHETIC TEST BLENDS)

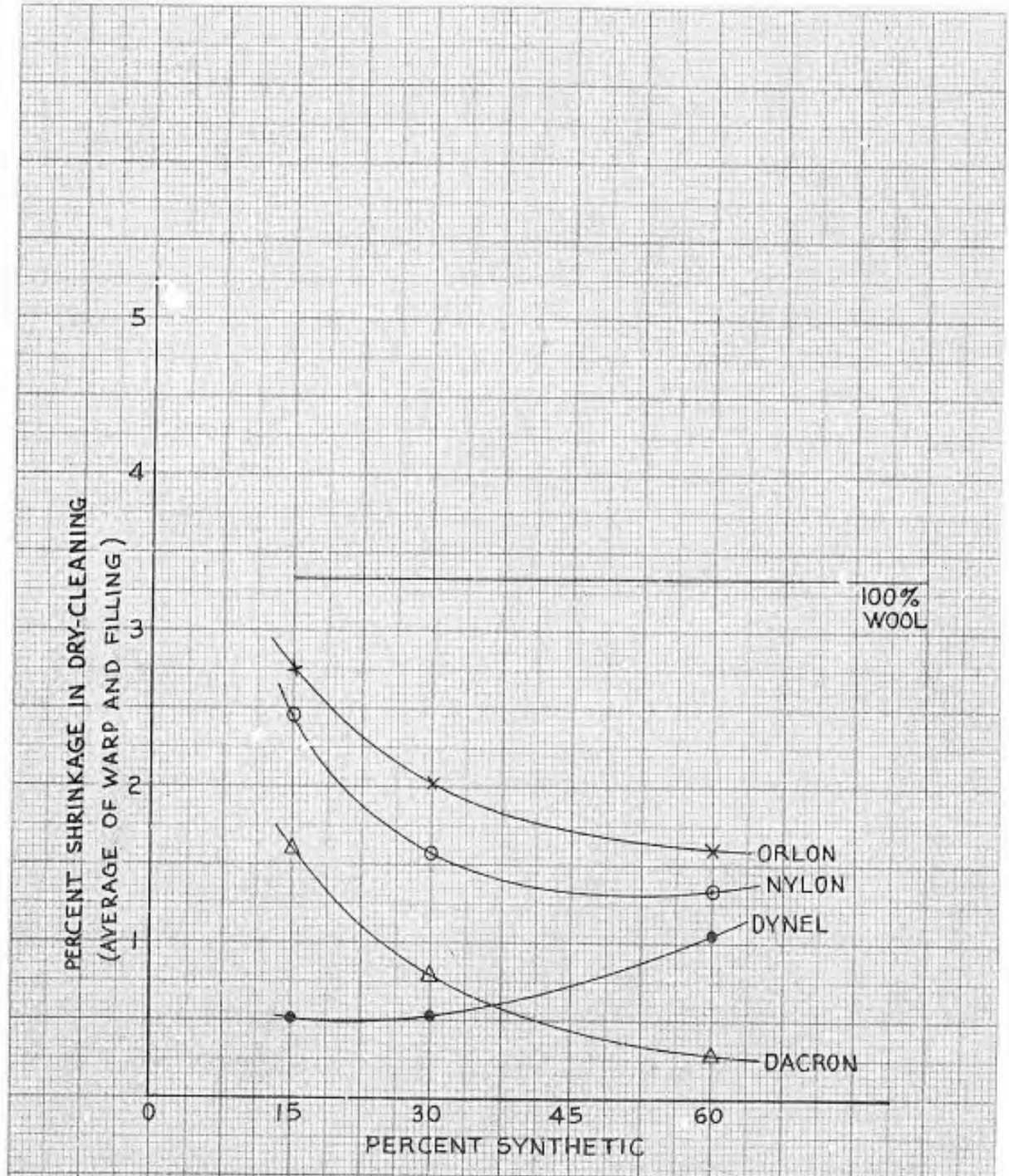

FIGURE 21 - SHRINKAGE IN DRY-CLEANING (WOOL-SYNTHETIC TEST BLENDS)

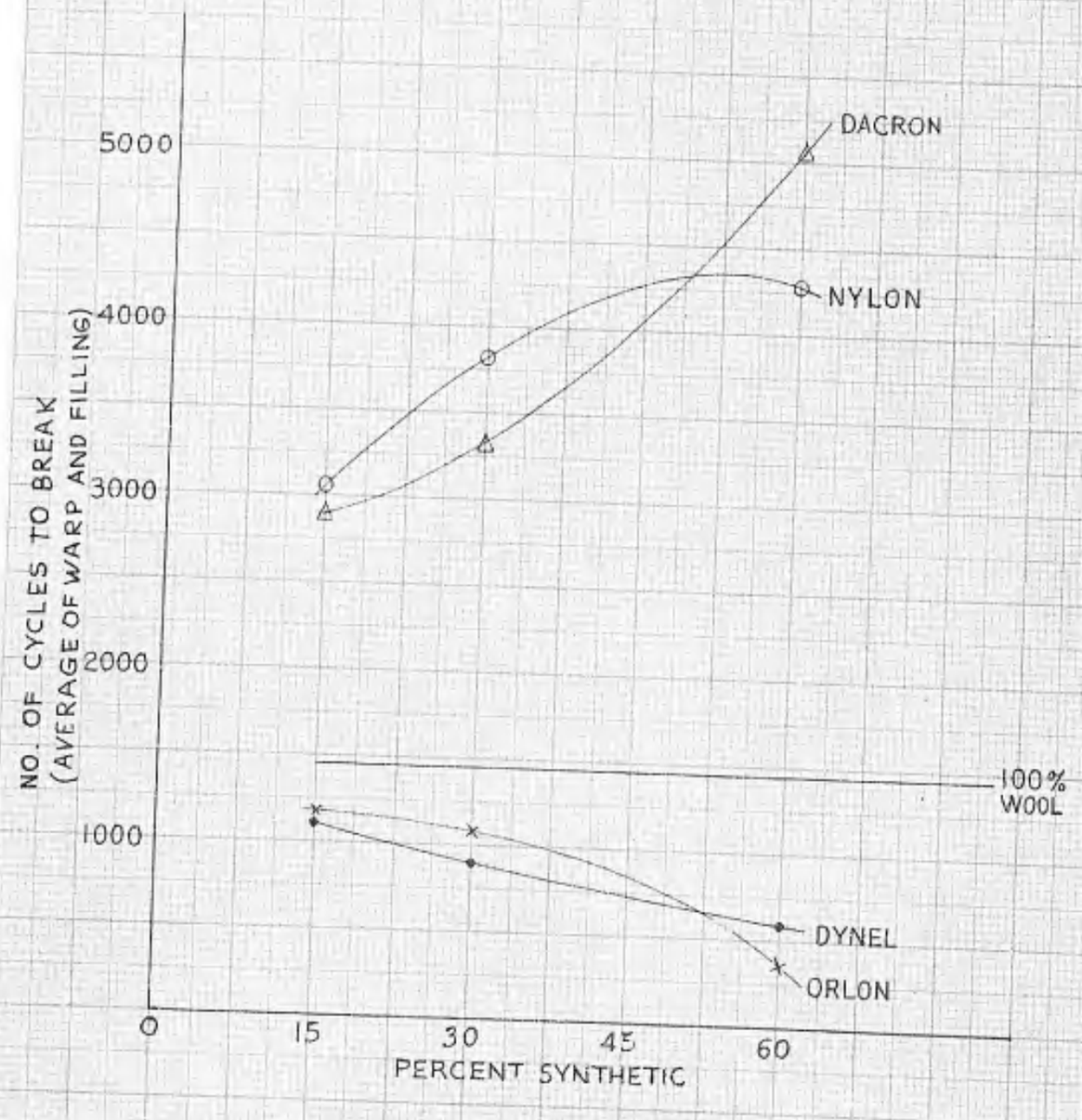

FIGURE 22–FLEX ABRASION(WOOL-SYNTHETIC TEST BLENDS)

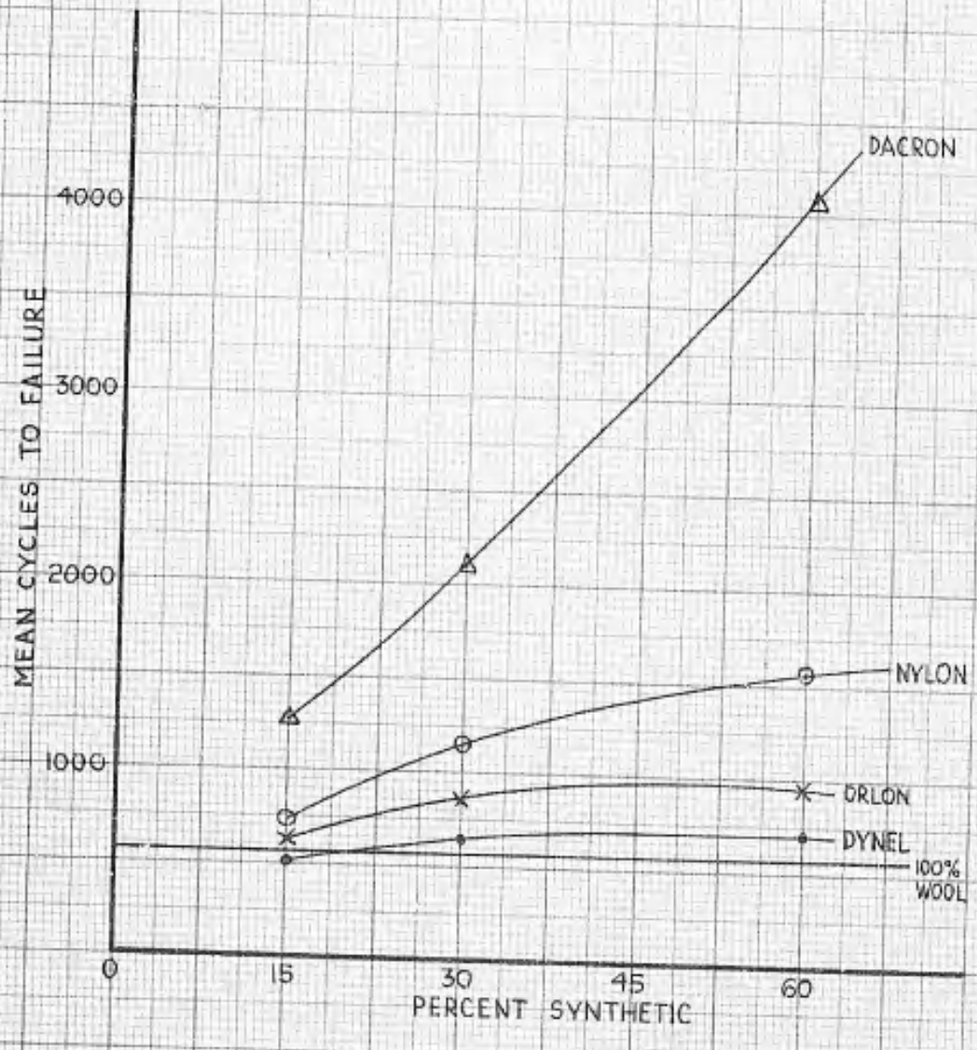

FIGURE 23 - SURFACE ABRASION (WOOL-SYNTHETIC TEST BLENDS)

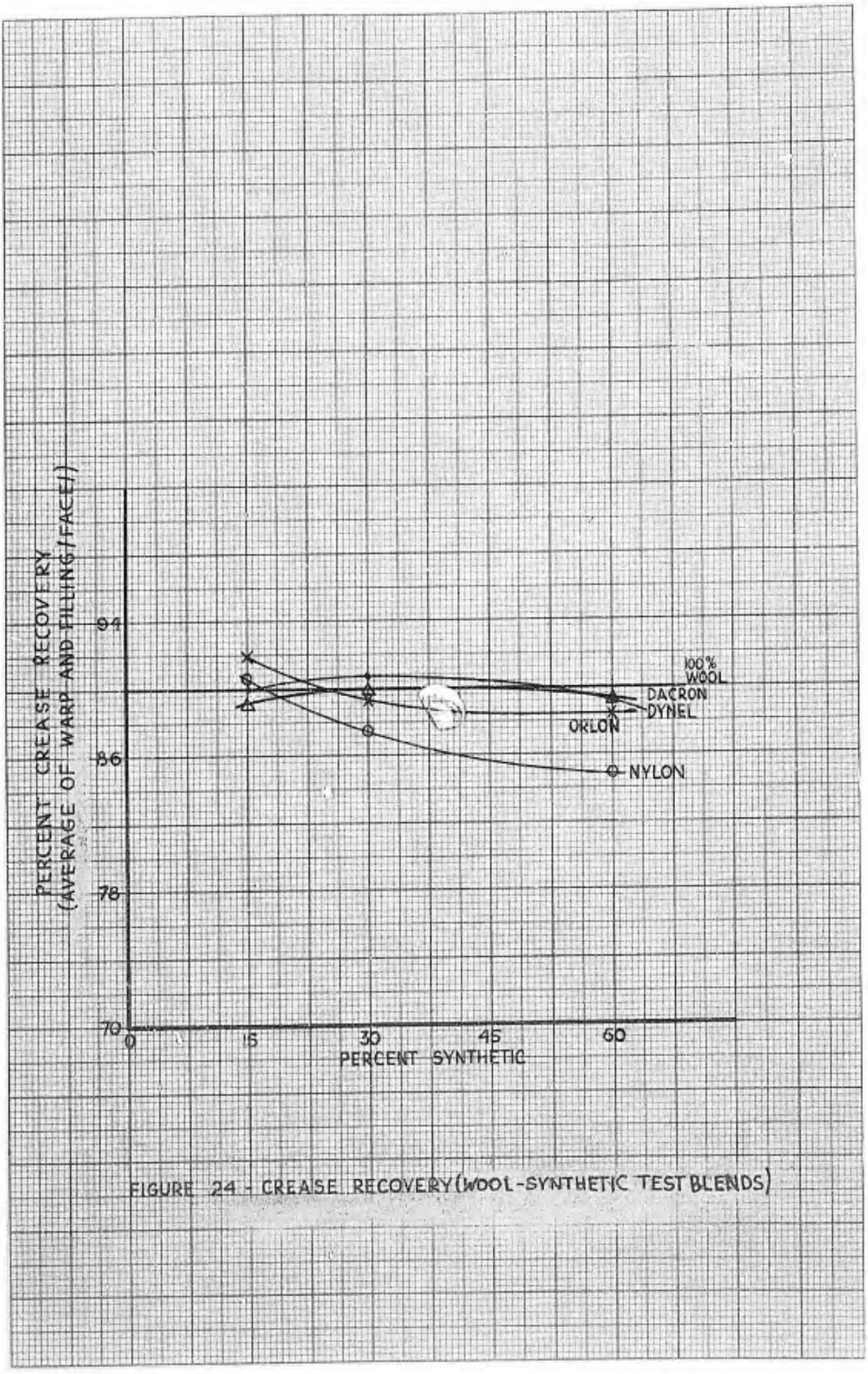

FIGURE 24 - CREASE RECOVERY (WOOL-SYNTHETIC TEST BLENDS)

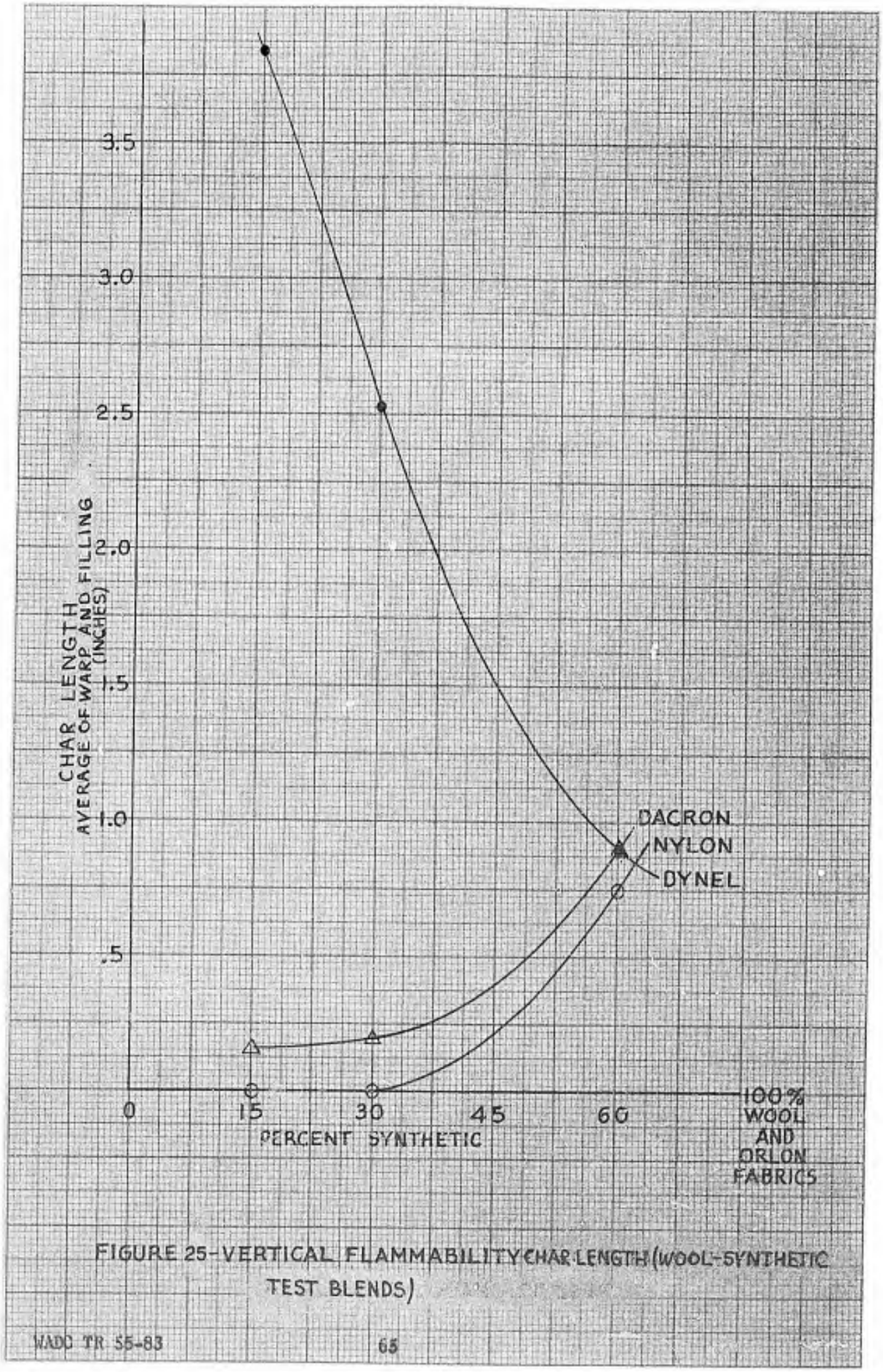

FIGURE 25-VERTICAL FLAMMABILITY CHAR LENGTH (WOOL-SYNTHETIC TEST BLENDS)

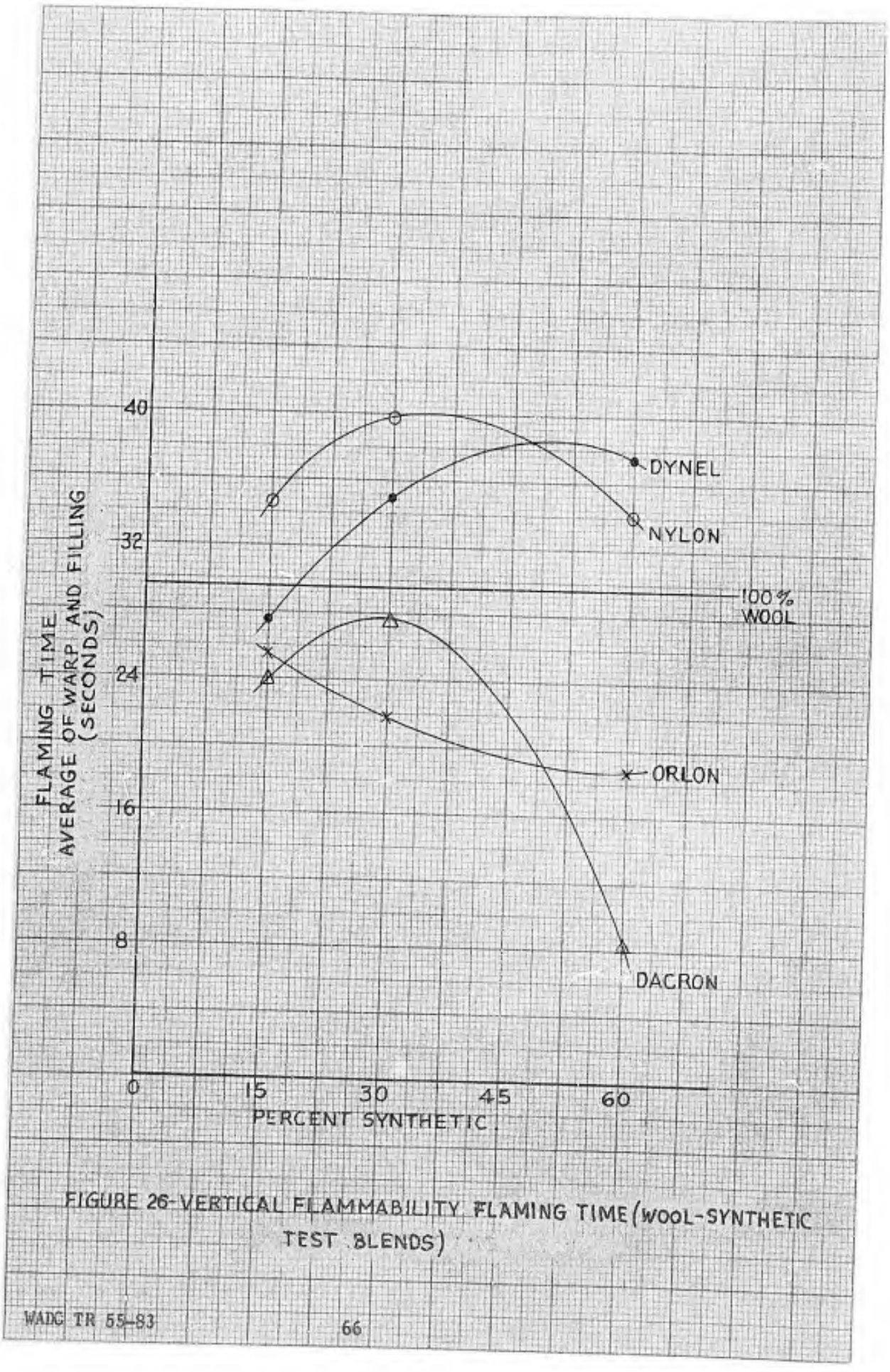

FIGURE 26- VERTICAL FLAMMABILITY FLAMING TIME (WOOL-SYNTHETIC TEST BLENDS)

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